GE Healthcare

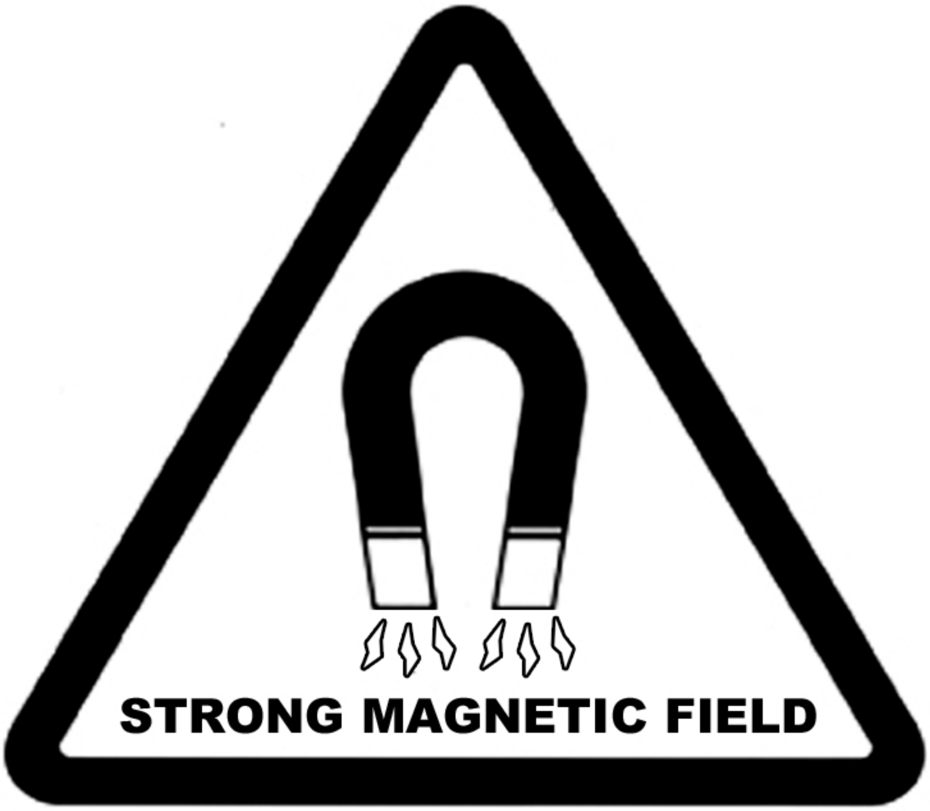
Optima MR450w

Preinstallation Manual

OPERATING DOCUMENTATION

5670001
Revision 3.0

WARNING





NO PACEMAKERS
NO METALLIC IMPLANTS

Persons with pacemakers, neurostimulators or metalic implants must not enter the magnet area. Serious injury may result.



NO LOOSE METAL OBJECTS

Iron and steel materials must not be taken into the magent area. Serious injury or property damage may result.

Important Information

LANGUAGE

ПРЕДУПРЕЖДЕНИЕ (BG)

Това упътване за работа е налично само на английски език.

- Ако доставчикът на услугата на клиента изиска друг език, задължение на клиента е да осигури превод.
- Не използвайте оборудването, преди да сте се консултирали и разбрали упътването за работа.
- Неспазването на това предупреждение може да доведе до нараняване на доставчика на услугата, оператора или пациента в резултат на токов удар, механична или друга опасност.

警告 (ZH-CN)

本维修手册仅提供英文版本。

- 如果客户的维修服务人员需要非英文版本，则客户需自行提供翻译服务。
- 未详细阅读和完全理解本维修手册之前，不得进行维修。
- 忽略本警告可能对维修服务人员、操作人员或患者造成电击、机械伤害或其他形式的伤 害。

警告 (ZH-HK)

本服務手冊僅提供英文版本。

- 倘若客戶的服務供應商需要英文以外之服務手冊，客戶有責任提供翻譯服務。
- 除非已參閱本服務手冊及明白其內容，否則切勿嘗試維修設備。
- 不遵從本警告或會令服務供應商、網絡供應商或病人受到觸電、機械性或其他的危險。

警告 (ZH-TW)

本維修手冊僅有英文版。

- 若客戶的維修廠商需要英文版以外的語言，應由客戶自行提供翻譯服務。
- 請勿試圖維修本設備，除非 您已查閱並瞭解本維修手冊。
- 若未留意本警告，可能導致維修廠商、操作員或病患因觸電、機械或其他危險而受傷。

UPOZORENJE (HR)

Ovaj servisni priručnik dostupan je na engleskom jeziku.

- Ako davatelj usluge klijenta treba neki drugi jezik, klijent je dužan osigurati prijevod.
- Ne pokušavajte servisirati opremu ako niste u potpunosti pročitali i razumjeli ovaj servisni priručnik.
- Zanemarite li ovo upozorenje, može doći do ozljede davatelja usluge, operatera ili pacijenta uslijed strujnog udara, mehaničkih ili drugih rizika.

VÝSTRAHA (CS)

Tento provozní návod existuje pouze v anglickém jazyce.

- V případě, že externí služba zákazníkům potřebuje návod v jiném jazyce, je zajištění překladu do odpovídajícího jazyka úkolem zákazníka.
- Nesnažte se o údržbu tohoto zařízení, aniž byste si přečetli tento provozní návod a pochopili jeho obsah.
- V případě nedodržování této výstrahy může dojít k poranění pracovníka prodejního servisu, obslužného personálu nebo pacientů vlivem elektrického proudu, respektive vlivem mechanických či jiných rizik.

ADVARSEL (DA)

Denne servicemanual findes kun på engelsk.

- Hvis en kundes tekniker har brug for et andet sprog end engelsk, er det kundens ansvar at sørge for oversættelse.
- Forsøg ikke at servicere udstyret uden at læse og forstå denne servicemanual.
- Manglende overholdelse af denne advarsel kan medføre skade på grund af elektrisk stød, mekanisk eller anden fare for teknikeren, operatøren eller patienten.

WAARSCHUWING (NL)

Deze onderhoudshandleiding is enkel in het Engels verkrijgbaar.

- Als het onderhoudspersoneel een andere taal vereist, dan is de klant verantwoordelijk voor de vertaling ervan.
- Probeer de apparatuur niet te onderhouden alvorens deze onderhoudshandleiding werd geraadpleegd en begrepen is.
- Indien deze waarschuwing niet wordt opgevolgd, zou het onderhoudspersoneel, de operator of een patiënt gewond kunnen raken als gevolg van een elektrische schok, mechanische of andere gevaren.

WARNING (EN)

This service manual is available in English only.

- If a customer's service provider requires a language other than English, it is the customer's responsibility to provide translation services.
- Do not attempt to service the equipment unless this service manual has been consulted and is understood.
- Failure to heed this warning may result in injury to the service provider, operator or patient from electric shock, mechanical or other hazards.

HOIATUS (ET)

See teenindusjuhend on saadaval ainult inglise keeles.

- Kui klienditeeninduse osutaja nõuab juhendit inglise keelest erinevas keeles, vastutab klient tõlketeenuse osutamise eest.
- Ärge üritage seadmeid teenindada enne eelnevalt käesoleva teenindusjuhendiga tutvumist ja sellest aru saamist.
- Käesoleva hoiatuse eiramine võib põhjustada teenuseosutaja, operaatori või patsiendi vigastamist elektrilöögi, mehaanilise või muu ohu tagajärjel.

VAROITUS (FI)

Tämä huolto-ohje on saatavilla vain englanniksi.

- Jos asiakkaan huoltohenkilöstö vaatii muuta kuin englanninkielistä materiaalia, tarvittavan käännöksen hankkiminen on asiakkaan vastuulla.
- Älä yritä korjata laitteistoa ennen kuin olet varmasti lukenut ja ymmärtänyt tämän huolto-ohjeen.
- Mikäli tätä varoitusta ei noudateta, seurauksena voi olla huoltohenkilöstön, laitteiston käyttäjän tai potilaan vahingoittuminen sähköiskun, mekaanisen vian tai muun vaaratilanteen vuoksi.

ATTENTION (FR)

Ce manuel d’installation et de maintenance est disponible uniquement en anglais.

- Si le technicien d'un client a besoin de ce manuel dans une langue autre que l'anglais, il incombe au client de le faire traduire.
- Ne pas tenter d'intervenir sur les équipements tant que ce manuel d’installation et de maintenance n'a pas été consulté et compris.
- Le non-respect de cet avertissement peut entraîner chez le technicien, l'opérateur ou le patient des blessures dues à des dangers électriques, mécaniques ou autres.

WARNUNG (DE)

Diese Serviceanleitung existiert nur in englischer Sprache.

- Falls ein fremder Kundendienst eine andere Sprache benötigt, ist es Aufgabe des Kunden für eine entsprechende Übersetzung zu sorgen.
- Versuchen Sie nicht diese Anlage zu warten, ohne diese Serviceanleitung gelesen und verstanden zu haben.
- Wird diese Warnung nicht beachtet, so kann es zu Verletzungen des Kundendiensttechnikers, des Bedieners oder des Patienten durch Stromschläge, mechanische oder sonstige Gefahren kommen.

ΠΡΟΕΙΔΟΠΟΙΗΣΗ (EL)

Το παρόν εγχειρίδιο σέρβις διατίθεται μόνο στα αγγλικά.

- Εάν ο τεχνικός σέρβις ενός πελάτη απαιτεί το παρόν εγχειρίδιο σε γλώσσα εκτός των αγγλικών, αποτελεί ευθύνη του πελάτη να παρέχει τις υπηρεσίες μετάφρασης.
- Μην επιχειρήσετε την εκτέλεση εργασιών σέρβις στον εξοπλισμό αν δεν έχετε συμβουλευτεί και κατανοήσει το παρόν εγχειρίδιο σέρβις.
- Αν δεν προσέξετε την προειδοποίηση αυτή, ενδέχεται να προκληθεί τραυματισμός στον τεχνικό σέρβις, στο χειριστή ή στον ασθενή από ηλεκτροπληξία, μηχανικούς ή άλλους κινδύνους.

FIGYELMEZTETÉS (HU)

Ezen karbantartási kézikönyv kizárólag angol nyelven érhető el.

- Ha a vevő szolgáltatója angoltól eltérő nyelvre tart igényt, akkor a vevő felelőssége a fordítás elkészíttetése.
- Ne próbálja elkezdeni használni a berendezést, amíg a karbantartási kézikönyvben leírtakat nem értelmezték.
- Ezen figyelmeztetés figyelmen kívül hagyása a szolgáltató, működtető vagy a beteg áramütés, mechanikai vagy egyéb veszélyhelyzet miatti sérülését eredményezheti.

AÐVÖRUN (IS)

Þessi þjónustuhandbók er aðeins fáanleg á ensku.

- Ef að þjónustuveitandi viðskiptamanns þarfnast annas tungumáls en ensku, er það skylda viðskiptamanns að skaffa tungumálaþjónustu.
- Reynið ekki að afgreiða tækið nema að þessi þjónustuhandbók hefur verið skoðuð og skilin.
- Brot á sinna þessari aðvörun getur leitt til meiðsla á þjónustuveitanda, stjórnanda eða sjúklings frá raflosti, vélrænu eða öðrum áhættum.

AVVERTENZA (IT)

Il presente manuale di manutenzione è disponibile soltanto in lingua inglese.

- Se un addetto alla manutenzione richiede il manuale in una lingua diversa, il cliente è tenuto a provvedere direttamente alla traduzione.
- Procedere alla manutenzione dell'apparecchiatura solo dopo aver consultato il presente manuale ed averne compreso il contenuto.
- Il mancato rispetto della presente avvertenza potrebbe causare lesioni all'addetto alla manutenzione, all'operatore o ai pazienti provocate da scosse elettriche, urti meccanici o altri rischi.

警告 (JA)

このサービスマニュアルには英語版しかありません。

- サービスを担当される業者が英語以外の言語を要求される場合、翻訳作業はその業者の責任で行うものとさせていただきます。
- このサービスマニュアルを熟読し理解せずに、装置のサービスを行わないでください。
- この警告に従わない場合、サービスを担当される方、操作員あるいは患者 さんが、感電や機械的又はその他の危険により負傷する可能性があります。

경고 (KO)

본 서비스 매뉴얼은 영어로만 이용하실 수 있습니다.

- 고객의 서비스 제공자가 영어 이외의 언어를 요구할 경우, 번역 서비스를 제공하는 것은 고객의 책임입니다.
- 본 서비스 매뉴얼을 참조하여 숙지하지 않은 이상 해당 장비를 수리하려고 시도하지 마십시오.
- 본 경고 사항에 유의하지 않으면 전기 쇼크, 기계적 위험, 또는 기타 위험으로 인해 서비스 제공자, 사용자 또는 환자에게 부상을 입힐 수 있습니다.

BRĪDINĀJUMS (LV)

Šī apkopes rokasgrāmata ir pieejama tikai angļu valodā.

- Ja klienta apkopes sniedzējam nepieciešama informācija citā valodā, klienta pienākums ir nodrošināt tulkojumu.
- Neveiciet aprīkojuma apkopi bez apkopes rokasgrāmatas izlasīšanas un saprašanas.
- Šī brīdinājuma neievērošanas rezultātā var rasties elektriskās strāvas trieciena, mehānisku vai citu faktoru izraisītu traumu risks apkopes sniedzējam, operatoram vai pacientam.

ĮSPĖJIMAS (LT)

Šis eksploatavimo vadovas yra tik anglų kalba.

- Jei kliento paslaugų tiekėjas reikalauja vadovo kita kalba – ne anglų, suteikti vertimo paslaugas privalo klientas.
- Nemėginkite atlikti įrangos techninės priežiūros, jei neperskaitėte ar nesupratote šio eksploatavimo vadovo.
- Jei nepaisysite šio įspėjimo, galimi paslaugų tiekėjo, operatoriaus ar paciento sužalojimai dėl elektros šoko, mechaninių ar kitų pavojų.

ADVARSEL (NO)

Denne servicehåndboken finnes bare på engelsk.

- Hvis kundens serviceleverandør har bruk for et annet språk, er det kundens ansvar å sørge for oversettelse.
- Ikke forsøk å reparere utstyret uten at denne servicehåndboken er lest og forstått.
- Manglende hensyn til denne advarselen kan føre til at serviceleverandøren, operatøren eller pasienten skades på grunn av elektrisk støt, mekaniske eller andre farer.

OSTRZEŻENIE (PL)

Niniejszy podręcznik serwisowy dostępny jest jedynie w języku angielskim.

- Jeśli serwisant klienta wymaga języka innego niż angielski, zapewnienie usługi tłumaczenia jest obowiązkiem klienta.
- Nie próbować serwisować urządzenia bez zapoznania się z niniejszym podręcznikiem serwisowym i zrozumienia go.
- Niezastosowanie się do tego ostrzeżenia może doprowadzić do obrażeń serwisanta, operatora lub pacjenta w wyniku porażenia prądem elektrycznym, zagrożenia mechanicznego bądź innego.

ATENÇÃO (PT-BR)

Este manual de assistência técnica encontra-se disponível unicamente em inglês.

- Se outro serviço de assistência técnica solicitar a tradução deste manual, caberá ao cliente fornecer os serviços de tradução.
- Não tente reparar o equipamento sem ter consultado e compreendido este manual de assistência técnica.
- A não observância deste aviso pode ocasionar ferimentos no técnico, operador ou paciente decorrentes de choques elétricos, mecânicos ou outros.

ATENÇÃO (PT-PT)

Este manual de assistência técnica só se encontra disponível em inglês.

- Se qualquer outro serviço de assistência técnica solicitar este manual noutro idioma, é da responsabilidade do cliente fornecer os serviços de tradução.
- Não tente reparar o equipamento sem ter consultado e compreendido este manual de assistência técnica.
- O não cumprimento deste aviso pode colocar em perigo a segurança do técnico, do operador ou do paciente devido a choques eléctricos, mecânicos ou outros.

ATENŢIE (RO)

Acest manual de service este disponibil doar în limba engleză.

- Dacă un furnizor de servicii pentru clienți necesită o altă limbă decât cea engleză, este de datoria clientului să furnizeze o traducere.
- Nu încercați să reparați echipamentul decât ulterior consultării și înțelegerii acestui manual de service.
- Ignorarea acestui avertisment ar putea duce la rănirea depanatorului, operatorului sau pacientului în urma pericolelor de electrocutare, mecanice sau de altă natură.

ОСТОРОЖНО! (RU)

Данное руководство по техническому обслуживанию представлено только на английском языке.

- Если сервисному персоналу клиента необходимо руководство не на английском, а на каком-то другом языке, клиенту следует самостоятельно обеспечить перевод.
- Перед техническим обслуживанием оборудования обязательно обратитесь к данному руководству и поймите изложенные в нем сведения.
- Несоблюдение требований данного предупреждения может привести к тому, что специалист по техобслуживанию, оператор или пациент получит удар электрическим током, механическую травму или другое повреждение.

UPOZORENJE (SR)

Ovo servisno uputstvo je dostupno samo na engleskom jeziku.

- Ako klijentov serviser zahteva neki drugi jezik, klijent je dužan da obezbedi prevodilačke usluge.
- Ne pokušavajte da opravite uređaj ako niste pročitali i razumeli ovo servisno uputstvo.
- Zanemarivanje ovog upozorenja može dovesti do povređivanja servisera, rukovaoca ili pacijenta usled strujnog udara ili mehaničkih i drugih opasnosti.

UPOZORNENIE (SK)

Tento návod na obsluhu je k dispozícii len v angličtine.

- Ak zákazníkov poskytovateľ služieb vyžaduje iný jazyk ako angličtinu, poskytnutie prekladateľských služieb je zodpovednosťou zákazníka.
- Nepokúšajte sa o obsluhu zariadenia, kým si neprečítate návod na obluhu a neporozumiete mu.
- Zanedbanie tohto upozornenia môže spôsobiť zranenie poskytovateľa služieb, obsluhujúcej osoby alebo pacienta elektrickým prúdom, mechanické alebo iné ohrozenie.

ATENCION (ES)

Este manual de servicio sólo existe en inglés.

- Si el encargado de mantenimiento de un cliente necesita un idioma que no sea el inglés, el cliente deberá encargarse de la traducción del manual.
- No se deberá dar servicio técnico al equipo, sin haber consultado y comprendido este manual de servicio.
- La no observancia del presente aviso puede dar lugar a que el proveedor de servicios, el operador o el paciente sufran lesiones provocadas por causas eléctricas, mecánicas o de otra naturaleza.

VARNING (SV)

Den här servicehandboken finns bara tillgänglig på engelska.

- Om en kunds servicetekniker har behov av ett annat språk än engelska, ansvarar kunden för att tillhandahålla översättningstjänster.
- Försök inte utföra service på utrustningen om du inte har läst och förstår den här servicehandboken.
- Om du inte tar hänsyn till den här varningen kan det resultera i skador på serviceteknikern, operatören eller patienten till följd av elektriska stötar, mekaniska faror eller andra faror.

OPOZORILO (SL)

Ta servisni priročnik je na voljo samo v angleškem jeziku.

- Če ponudnik storitve stranke potrebuje priročnik v drugem jeziku, mora stranka zagotoviti prevod.
- Ne poskušajte servisirati opreme, če tega priročnika niste v celoti prebrali in razumeli.
- Če tega opozorila ne upoštevate, se lahko zaradi električnega udara, mehanskih ali drugih nevarnosti poškoduje ponudnik storitev, operater ali bolnik.

DİKKAT (TR)

Bu servis kılavuzunun sadece ingilizcesi mevcuttur.

- Eğer müşteri teknisyeni bu kılavuzu ingilizce dışında bir başka lisandan talep ederse, bunu tercüme ettirmek müşteriye düşer.
- Servis kılavuzunu okuyup anlamadan ekipmanlara müdahale etmeyiniz.
- Bu uyarıya uyulmaması, elektrik, mekanik veya diğer tehlikelerden dolayı teknisyen, operatör veya hastanın yaralanmasına yol açabilir.

This page left intentionally blank.

Revision History

Revision	Date	Description		
1.0	01July2009	Initial Release		
2.0	01Dec2009	Document review and approval per DOC0675763 R2 V3		
		iTrak No.	**Ch, Sec No.**	**Change**
		13252239	Ch 6, Sec 1.3	Added Brainwave cable information
		13230415	Ch 3, Sec 8.2	Clarified Incoming air must contain 5% outside air (from outside the room)
		13254391	Ch 4, Sec 5	Updated Pen cabinet installed height and width
		SPR No.		
		MRIhc45228; MRIhc45709	Ch 6, Sec 3	Updated system cable list
		MRIhc45702	Ch 2, Sec 11	Standby (no scan) missing, should be 17 kVA
			Ch 2, Sec 3	Missing dimension on illustration 2-2 (Front of Magnet to front of service area = 103.5 in.)
			Ch 2, Sec 8.2	79.2 in. is shown as is 3000 mm. Should be 79 (2000)
			Ch 3, Sec 5.4	Missing RF survey specifications (same as 450). Add back in.
			Ch 3, Sec 5.6	Magnet anchor drawing titled “Magnet and Dock Anchor Mounting Details”
		MRIhc45703	Ch 3, Sec 2.2	Updated steel limit table (distance from isocenter values)
		MRIhc45705	Ch 3, Sec 5.2.5	Updated RF shielding test requirement from 150 MHz to 100 MHz (with recommendation for 150 MHz for new construction to accommodate upgrades)
		MRIhc45706	Ch 4, Sec 4; Ch 4, Sec 5	Updated gauss limits for PEN and HEC cabinets to 50 Gauss
		MRIhc45707	Ch 2, Sec 4	Updated EMC declaration per 60601-1-2 Edition 2.1
		MRIhc45708	Ch 3, Sec 7.2	Updated Table Illustration to show DV table (minor dimension changes)
		MRIhc45709	Ch 2, Sec 9; Ch 6, Sec 4	Added/updated Facility cooling requirements and hose/hose insulation specifications
		MRIhc45714	Ch 3, Sec 9.3	Updated Common Ground Stud requirement to increase allowable filter and pipe distances
		MRIhc45715	Ch 2, Sec 11	Changed MDP Regulation specification to 2%
		MRIhc45718	Ch 3, Sec 6.4	Added Vibromat dimensions to allow floor loading calculations
		MRIhc46104	Ch 2, Sec 12.3	PEN, HEC, PGR, SPW cabinet shipping dimensions updated
		MRIhc46124	Ch 3, Sec 6.3.1	Added ceiling interface drawing and requirements
		Other		
			Ch 2, Sec 10	Illustration 2-15, changed "Top of HEC" to “Terminal Strip” and remove E3027
		ECO 2076814	Ch 3, Sec 7.3	New MRU specifications and requirements added
			Ch 4, Sec 2	New MDP Updates

Revision	Date	Description		
			Ch 2, Sec 2.2; Ch 3, Sec 5.2.6; Ch 4; Ch 6 Sec 2; Ch 6, Sec 4	Added MRE requirements and specifications
			Ch 4, Sec 7	Updated PEN Panel mounting drawing
3.0	Nov2010	**Document review and approval per DOC0675763 R3 V4**		
		SPR		
		MRIhc52309	Ch 6, Sec 2	Updated distance from magnet isocenter to end of cable tray to 31.5 in. for Gradient cables; 26.5 in. for all other interconnects
		MRIhc51081	Ch 2, Sec 3	Updated Ch 2, Sec 3, Ill. 2-2 to remove 11" optional ceiling height requirement
		MRIhc47102, MRIhc47103	Ch 4, Sec 11	Changed input power requirements to MDP: 415/400/380 VAC 50 Hz
		MRIhc49467	Ch 3, Sec 5.5, 5.6	Updated Illustration 3-3: Magnet or Dock Anchor Mounting Details to show magnet feet flush with the floor.
		MRIhc50449	Ch 3, Sec 5.5, 5.6	Added maximum bolt length to both sections
		MRIhc51083	Ch 3, Sec 4	Clarified text
		MRIhc51455	Ch 3, Sec 7.3	Added remote MRU note
		MRIhc51974	Ch 3, Sec 6.1	Added air flow rate of 400CFM into the PEN closet
		MRIhc48846	Ch 2, Sec 5; Ch 7, Sec 3 and 4	RF Shielded room requirements updated. RF shielded room testing guidelines updated.
		MRIhc50268	Ch 6, Sec 2	Cable tray requirements updated
		MRIhc51454	Multiple	A. Pen Panels should be 118 (3000) in illustration 2-11 B. 5 (127) should be 2.5 (64) in ill. 3-6 C. Illustration titles 2-7 and 2-8 are reversed top/side views
		MRIhc51746	Ch 2, Sec 10	Added charts for coolant specifications (for clarity)
		MRIhc51442	Ch 3, Sec 8.5	Removed Ventglas requirement for dielectric break outside Magnet room; Added 0.25 in tolerance to vent location
		MRIhc51080	Ch 6, Sec 3	Updated system cable list
		MRIhc51082	Ch 4, Sec 2	Clarified cable strain relief dimensions on PGR cabinet
		MRIhc51352	Ch 2, Sec 11, Ill. 2-14; Ch 6, Sec 4, Ill 6-11	Clarified that E-Off location and wiring is determined by customer
		MRIhc51413	Ch, Sec 2, Ill. 2-1; Ch 3, Sec 7.2	Added optional surgical suite table illustration
		MRIhc49328; MRIhc51413	Ch 3, Sec 6	Added recommendations not to use ferrous material/components in the Magnet room
		MRIhc49327	Ch 2, Sec 10.2	Updated Emergency Coolant Requirements for clarity

Table of Contents

Chapter 1 Introduction

1 Preinstall Manual Introduction

WARNING

EQUIPMENT FAILURE OR PERSONNEL INJURY
FAILURE TO IMPLEMENT ALL REQUIREMENTS AND ADHERE TO ALL SPECIFICATIONS IN THIS MANUAL MAY RESULT IN PERSONAL INJURY, EQUIPMENT DAMAGE, SCAN FAILURE, OR WARRANTY VOID.
THE IMPLEMENTATION OF ALL REQUIREMENTS AND ADHERENCE TO ALL SPECIFICATIONS IN THIS MANUAL IS THE RESPONSIBILITY OF THE CUSTOMER OR THEIR ARCHITECT AND ENGINEERS. REFER ANY QUESTIONS TO THE GE HEALTHCARE PROJECT MANAGER OF INSTALLATION (PMI).

NOTICE

The customer is responsible for compliance with all local and National codes and regulations.

1.1 Document Purpose

This preinstallation manual provides the necessary information to prepare a site for system installation. Specifically, this manual provides information:

1. For the site to meet system requirements
2. For the effective arrangement and interconnection of system components

1.2 Intended User

The primary user of this manual is the customer's installation or architectural planner who has knowledge of the following:

1. MR nomenclature, system functions, and general characteristics
2. National and local building codes
3. Customer site procedures (medical, MR, safety, etc.)
4. Any special architectural requirements (e.g., seismic codes)

1.3 Document Overview

This manual describes requirements and specifications for the following:

1. General System Requirements
2. Shipping and Delivery
3. Magnet Room

4. Equipment Room
5. Control Room
6. Interconnects

Chapter 2 General System Level

1 Upgrade Requirements

When planning for the installation the Optima MR450w system in an existing GE Healthcare MR suite, all requirements in this manual must be met. Ensure the following:

NOTE: When planning installation in a non-GE Healthcare MR suite all requirements in this manual must be met.

1. For the vibration environmental assessment, the magnetic field stability tests (HSS tool) can be used (for GE cylindrical magnets only)
2. Remove, cover, or fill-in abandoned ducts or troughs and remove access/computer room flooring from the Equipment and Magnet rooms
3. The VibroAcoustic dampening kit must be surface mounted
4. Cable trays must have a clear path in the Magnet Room (see Chapter 6, MR System Interconnects Routing Requirements). Move HVAC duct, sprinkler pipe, lights, etc. if necessary
5. RF vendor responsibilities:
    a. Dock anchor placement (anchor is located after magnet installation)
    b. The RF shield ceiling must support the cable routing mechanism and cables. Reinforce RF shield ceiling (see Chapter 6, MR System Interconnects Routing Requirements)
    c. Dielectric breaks are required to support the cable trays
    d. Two penetration panel openings are required and must meet the requirements in: Chapter 4, PEN and SPW Wall Opening Requirements (includes PEN and SPW panels)
    e. RF shield attenuation must comply with: Chapter 3, RF Shielded Room Requirements
6. Install cable trays in equipment room (see Chapter 6, MR System Interconnects Routing Requirements)
7. Cryogen vent must be relocated to align with the Magnet Cryogen Vent opening (see Chapter 3, Magnet Room Venting Requirements)

2 System Components

The Optima MR450w system consists of the following components:

2.1 Magnet Room

1. 1.5T Magnet and Magnet Enclosure (MAG)
2. Rear Pedestal (PED)
3. Patient Transport Table (PT)
4. Optional, Surgical suite table
5. Magnet Rundown Unit (MRU). Note: An optional remote MRU may be located outside the magnet room.

2.2 Equipment Room

1. Main Disconnect Panel (MDP)
2. Power, Gradient, RF Cabinet (PGR)
3. Heat Exchanger Cabinet (HEC)
4. Penetration Panel Cabinet (PEN)
5. Secondary Penetration Wall (SPW)
6. Cryocooler Compressor Cabinet (CRY)
7. Magnet Monitor (MON)
8. Optional: Brainwave Lite (BW)
9. Optional: CADstream
10. Optional: MR Guided Focus Ultrasound (FUS)
11. Optional: Magnetic Resonance Elastography (MRE)

2.3 Control Room

1. Operator Workspace equipment (OW)
2. Pneumatic Patient Alert System (PA1)
3. Optional, Oxygen Monitor (OXY)

2.4 Accessories

1. Patient accessories, including phantoms, cushions, sponges, straps, and wedges
2. Gating accessories, including patient cardiac leads, peripheral gating probe, and respiratory bellows

3 MR Suite Minimum Room Size Requirements

Room dimensions shown in the table below lists the minimum finished room space requirements to properly and safely operate and service the MR system. This space must be kept clear of permanent or installed cabinetry, fixtures, etc. that would interfere with the service access area. The items listed below are not included in the minimum area dimensions:

1. Building code requirements (e.g., exit routes, door placement, local and national electrical codes, etc.)

   NOTE: The customer must provide Equipment and Magnet Room evacuation routes to comply with facility emergency procedures.

2. System requirements, including cable run locations, cryogen venting, patient observation requirements, and penetration panel placements (e.g., the Equipment room and Magnet room must share a common wall to allow penetration panel installation)
3. Penetration closet (must be outside the minimum finished room dimensions)
4. Non-GEHC equipment options (such as additional AC or water cooling equipment in the Equipment room)
5. Accessory storage. Refer to the *Customer Site Storage Requirements* manual (document number 5182674) or contact the GE Healthcare Project Manager of Installation (PMI) for any additional accessory storage requirements

Table 2-1: Minimum Finished Room Dimensions

Configuration	Equipment Room		Magnet Room (See the illustrations below for specific dimensions)			Control Room		Total System Area ft² (m²)
	Area ft² (m²)	Ceiling Height in. (mm)	W x D in. (mm)	Area ft² (m²)	Finished Ceiling Height in. (mm)	W x D in. (mm)	Area ft² (m²)	
Minimum Room Size (2050 mm Scan Range)	116.68 (10.84)	114 (2896)	143.5 x 245 (3620 x 6223)	Option 1: 222.49 (20.67) Option 2: 218.72 (20.32)	105 (2667) Minimum Ceiling: 98.5 (2500)	60 x 84 (1524 x 2134)	35 (3.2)	369.85 (34.36)
With MR Guided Focused Ultrasound	Contact the Project Manager of Installation (PMI) for FUS site planning details.							
With CADStream							Add: 1.25 (0.11)	
With Brainwave	Add: 13.25 (1.25)							

NOTE: Low ceiling kit is required if the ceiling height is 105 in. (2667) or less.

Illustration 2-1: Minimum Magnet Service Area

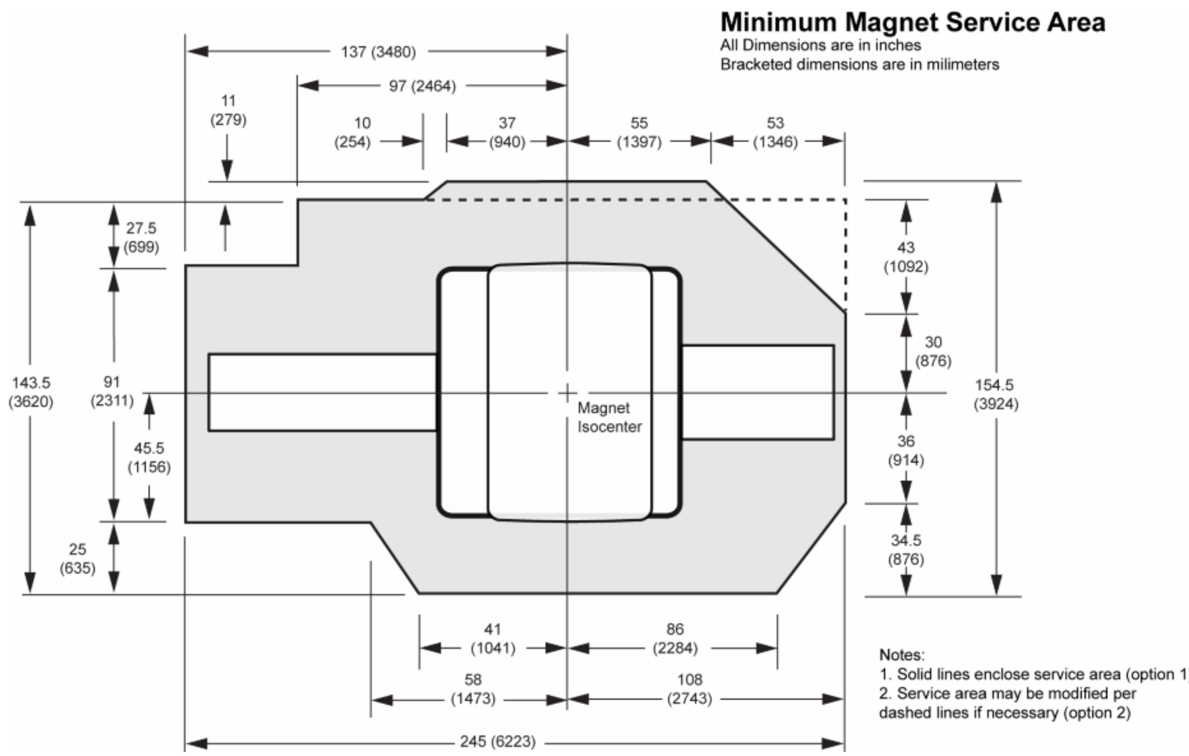


Illustration 2-2: Minimum Magnet Ceiling Height

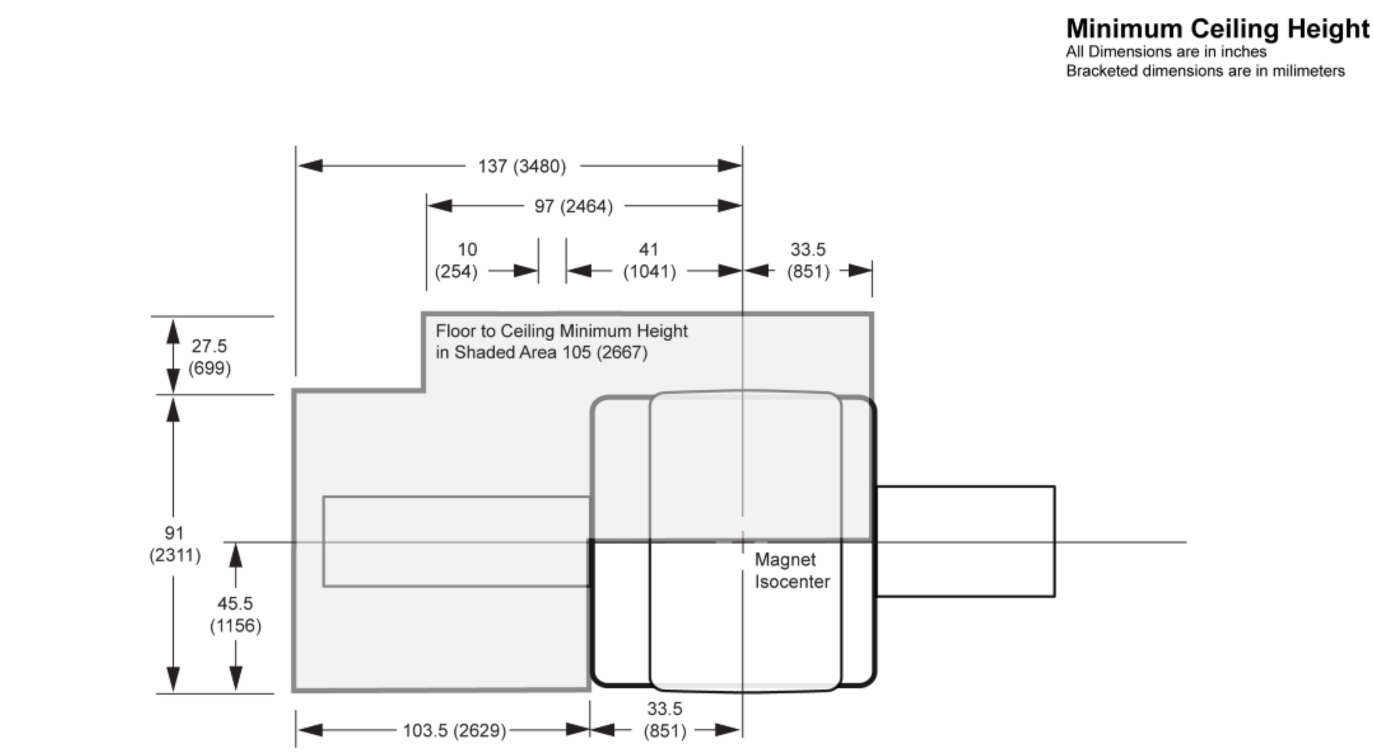
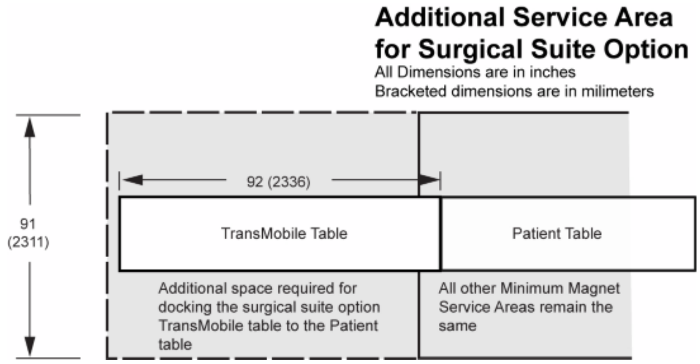


Illustration 2-3: Surgical Suite Optional Area



NOTE: Contact the GE Healthcare Project Manager of Installation (PMI) for additional information or to request designs.

4 IEC EMC Compliance

Per IEC 60601-1-2 Edition 2.1 Medical Electrical Equipment requires special precautions regarding Electromagnetic Compatibility (EMC) and must be installed and put into service according to the EMC information provided in the following tables. Full declaration is stored on-site in the user manual delivered with the system.

The MR system is designed and tested to the following standards:

Table 2-2: Guidance And Manufacturer's Declaration – Electromagnetic Emissions

The system is intended for use in the electromagnetic environment specified below. The customer or the user of the system should assure that it is used in such an environment.		
Emissions Test	**Compliance**	**Electromagnetic Environment – Guidance**
RF Emissions CISPR 11	Group 2	The system must emit electromagnetic energy in order to perform its intended function. Nearby electronic equipment may be affected
RF Emissions CISPR 11	Class A	The system is suitable for use in all establishments other than domestic and those directly connected to the public low-voltage power supply network that supplies buildings used for domestic purposes

Table 2-3: Guidance And Manufacturer's Declaration – Electromagnetic Immunity

The system is intended for use in the electromagnetic environment specified below. The customer or the user of the system should assure that it is used in such an environment.		
Immunity test	**IEC 60601 test level**	**Compliance Level**
Electrostatic discharge (ESD) IEC 61000-4-2	±6 kV contact	±6 kV contact
	±8 kV air	±8 kV air
Electrical fast transient / burst IEC 61000-4-4	±2 kV for power supply lines	±2 kV for power supply lines
	±1 kV for input/output lines	±1 kV for input/output lines
Surge IEC 61000-4-5	±1 kV line(s) to line(s)	±1 kV differential mode
	±2 kV line(s) to earth	±2 kV common mode
Voltage dips, short interruptions and voltage variations on power supply input lines IEC 61000-4-11	<5 % U_T (>95 % dip in U_T) for 5 sec.	<5 % U_T (>95 % dip in U_T) for 5 sec.
Power Frequency (50/60Hz) magnetic field IEC 61000-4-8	3 A/m	3 A/m
Conducted RF IEC 61000-4-6	3 Vrms 150 kHz to 80 MHz	3 Vrms
Radiated RF IEC 61000-4-3	3 V/m 80 MHz to 2,5 GHz	3 V/m

5 MR System Seismic Requirements

Contact the Project Manager of Installation with any questions.

1. The customer is responsible for seismic anchoring of GE components
2. Center of gravity, weight, physical dimensions, and attachment points are provided for seismic calculations. Refer to the specifications or illustrations for each component

6 MR Suite Acoustic Specifications

6.1 Acoustic Specifications

The following table lists the acoustic output of GE Healthcare equipment:

Table 2-4: Acoustic Specifications

	GE Equipment Acoustic Output	Notes
Control Room	62 dBA	
Equipment Room	80 dBA	The 80 dBA level is for GE equipment only. The Equipment room acoustic level must not exceed 85 dBA
Magnet Room	See Chapter 3, Acoustic Room Specifications	

Refer to Chapter 7, Acoustic Background and Design Guidelines

NOTE: All GE equipment acoustic output values are for base equipment configuration in each room.

6.2 Structureborne Vibration Control Specifications

Structureborne acoustic issues tend to occur at MR installations above the ground floor of the facility. Two options to mitigate structureborne acoustic transmission are:

1. GE Healthcare provides a VibroAcoustic Dampening kit (which must be surface mounted). Contact the GE Healthcare Project Manager of Installation for information
2. The customer may design and implement a custom solution in addition to the VibroAcoustic Dampening kit

NOTE: The amount of vibration attenuation provided by the VibroAcoustic Dampening kit will be site dependent.

7 MR Suite Magnetic Field Specifications

7.1 Magnetic Fringe Field

The following illustrations show the static magnet isogauss plot lines for a 1.5T magnet. This information must be used to evaluate potential site interaction of GE Healthcare equipment with other non-GE Healthcare equipment, interaction with magnetic materials on the site, and to locate personnel and equipment within the site.

The 5 gauss line can expand to 14.27 ft (4.35 m) axially and 9.35 ft (2.85 m) radially for up to 1 second in the rare event of a quench

These isogauss plots show an idealized magnetic field relative to magnet isocenter. The actual field strength can be affected by any of the following:

- Magnetic shielding
- Earth's magnetic field
- Other magnetic fields
- Stationary or moving metal

Illustration 2-4: Magnetic Fringe Field Side View

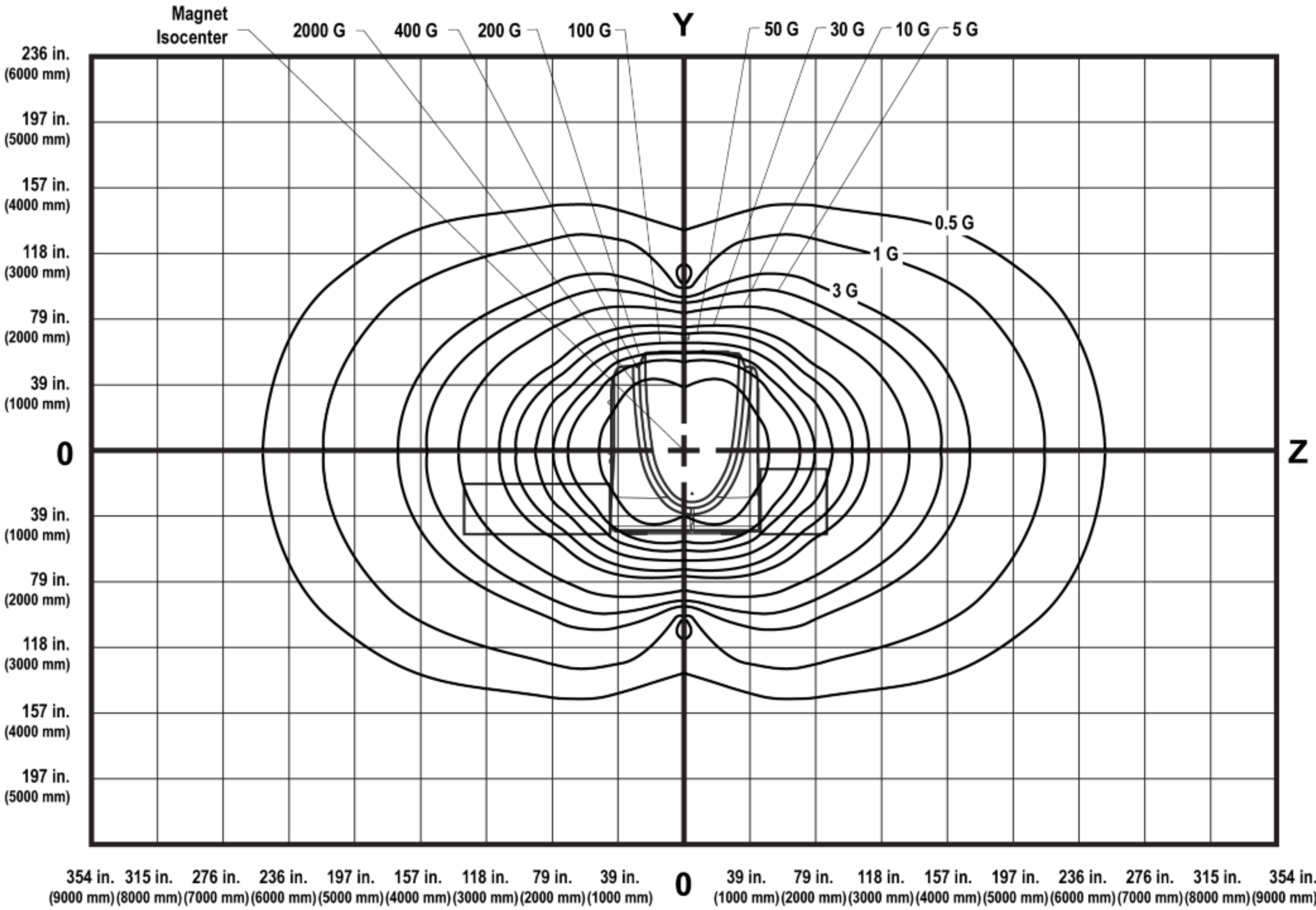


Illustration 2-5: Magnetic Fringe Field Top View

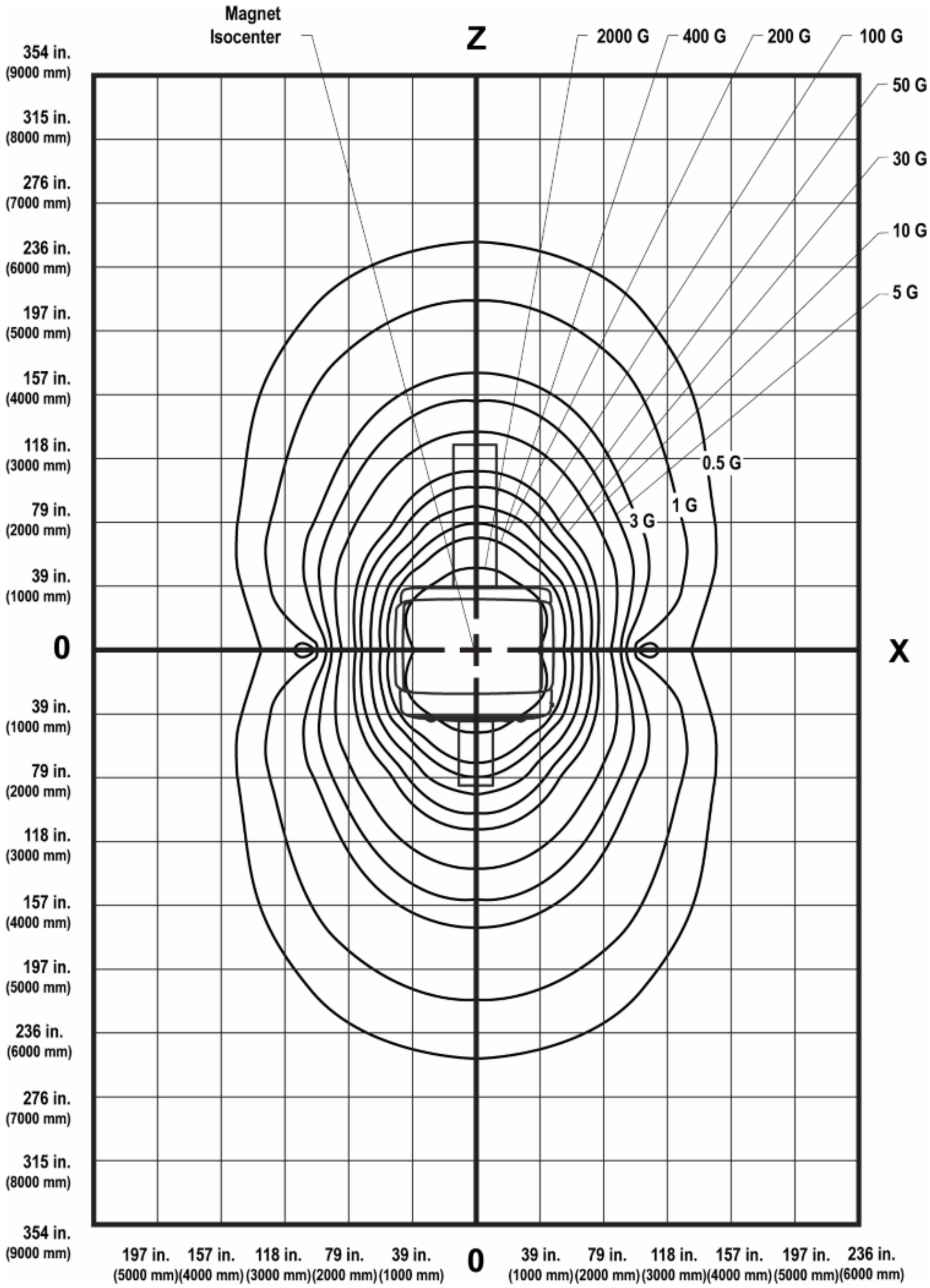
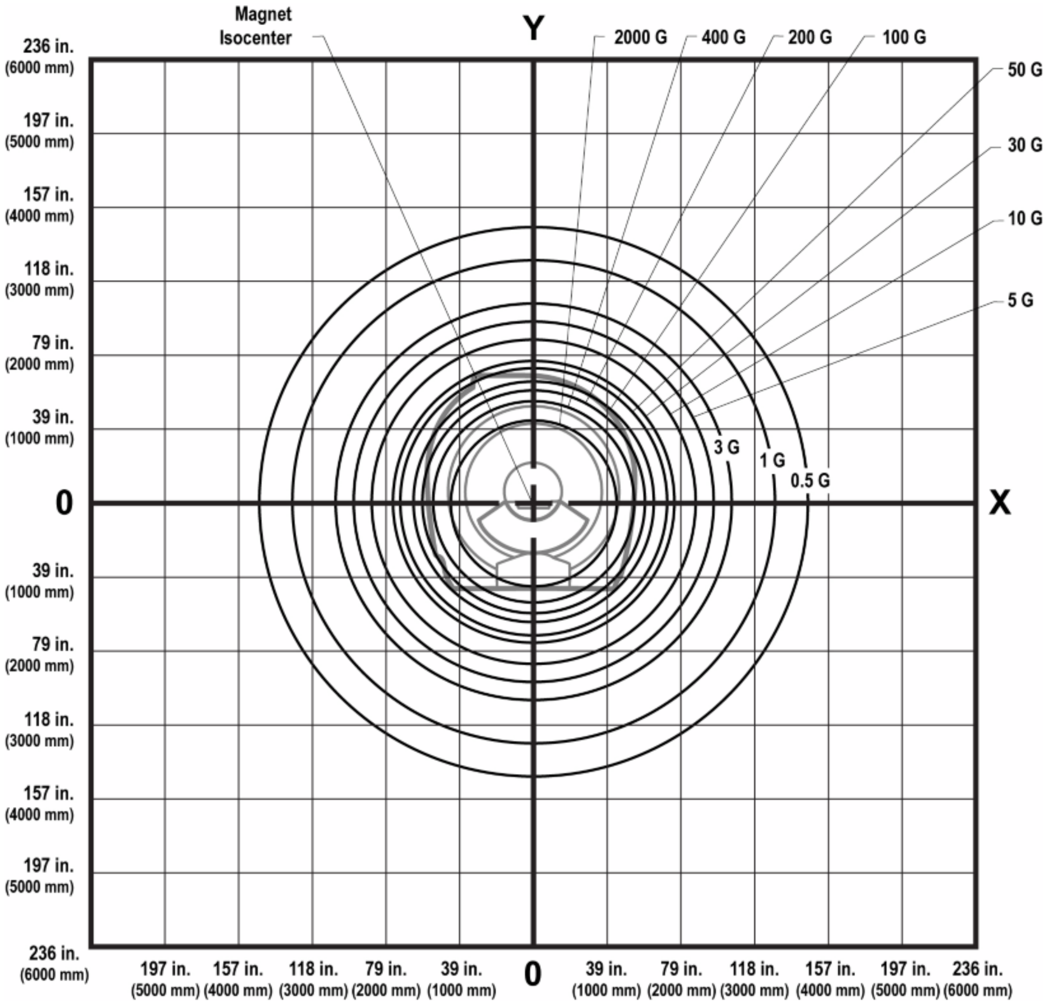


Illustration 2-6: Magnetic Fringe Field Front View



7.2 Interference from Changing Magnetic Fields

Metal objects moving within the magnet sensitivity lines can produce a field disturbance during clinical imaging. If the metal object is moving it will produce a fluctuating dipole type of field which cause image artifacts. As an example, a car driven inside the moving metal line will act as a dipole and produce a time varying field which change the magnet's main field during the imaging time. The same vehicle may park within the moving metal line and remain parked during clinical scanning without impact to the main field. See Illustration 2-7 and Illustration 2-8 .

Illustration 2-7: Magnet Moving Metal Sensitivity Line Plot (Side View)

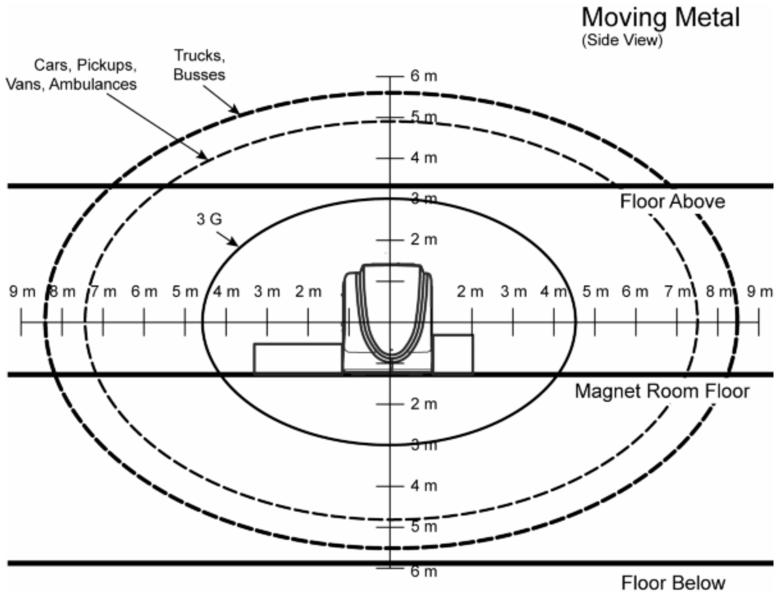


Illustration 2-8: Magnet Moving Metal Sensitivity Line Plot (Top View)

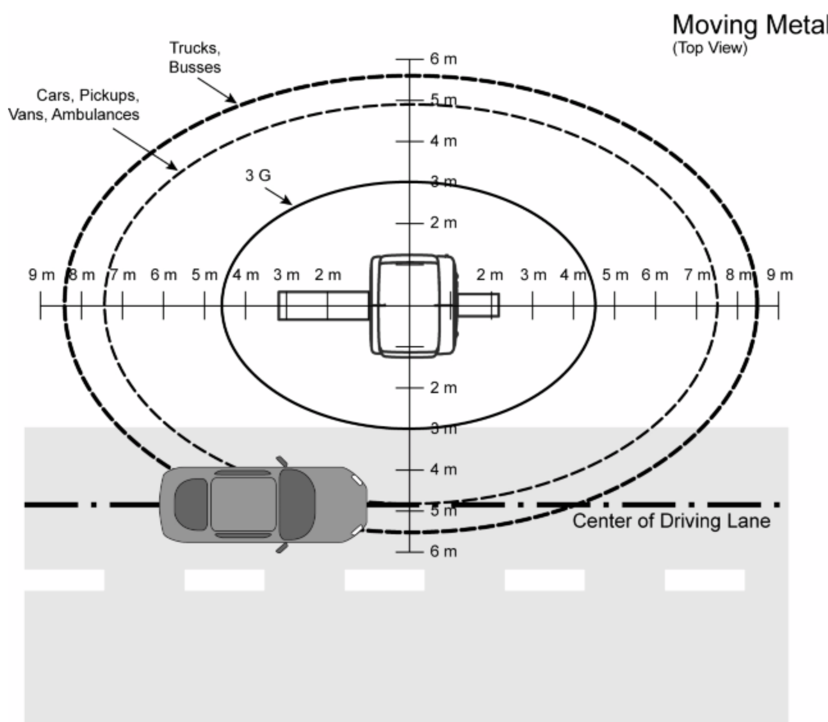


Table 2-5: Magnet Moving Metal Requirements

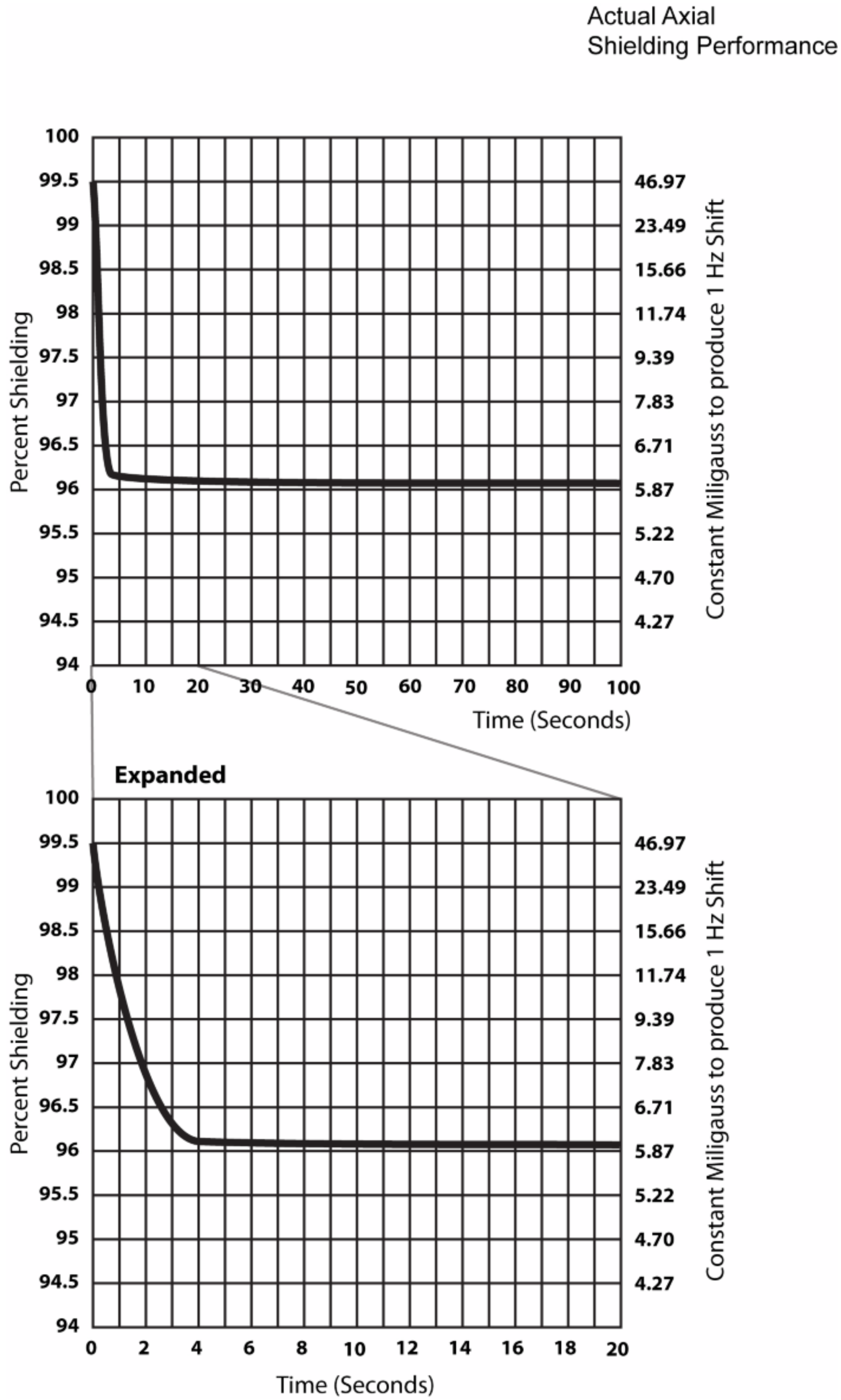
Metal Objects Category	Definition Of Distance Location	Magnet Minimum Distance Radial X Axial ft (m) See Note 1
Objects 100 - 400 lbs	Distance from isocenter radial x axial	3 Gauss line
Cars, Minivans, Vans, Pickup Trucks, Ambulances	Distance from isocenter measured to center of driving or parking lane radial x axial	15.5 x 24.6 (4.72 x 7.5)

Metal Objects Category	Definition Of Distance Location	Magnet Minimum Distance Radial X Axial ft (m) See Note 1
Bus, Trucks (Utility, Dump, Semi)	Distance from isocenter measured to center of driving or parking lane radial x axial	18.1 x 28.75 (5.52 x 8.76)
Objects > 400 lbs, Elevators, Trains, Subways	Place a directional probe (e.g. flux gate sensor) at isocenter of proposed magnet location aligned along the Z-axis. Measure peak-to-peak magnetic field change (DC).	Refer to Illustration 2-9 and notes below:

Notes:

1. Radial distances are magnet X and Y axis. Axial distances are magnet Z axis.
2. EXAMPLE: For Moving Metal Requirements of objects > 400 lbs category you can use the time history of the occurrence to determine what milligauss level to use.
    a. If the site has elevators/counter weights near the magnet and the elevator can stop on the floors for longer than 20 seconds (which is usually the case), peak-to-peak milligauss reading must be less than 5.87.
    b. If the site has a subway nearby and the field disturbance is less than 2 seconds, the peak-to-peak milligauss reading must be less than 5.87.
    c. Use 5.87 milligauss peak-to-peak.

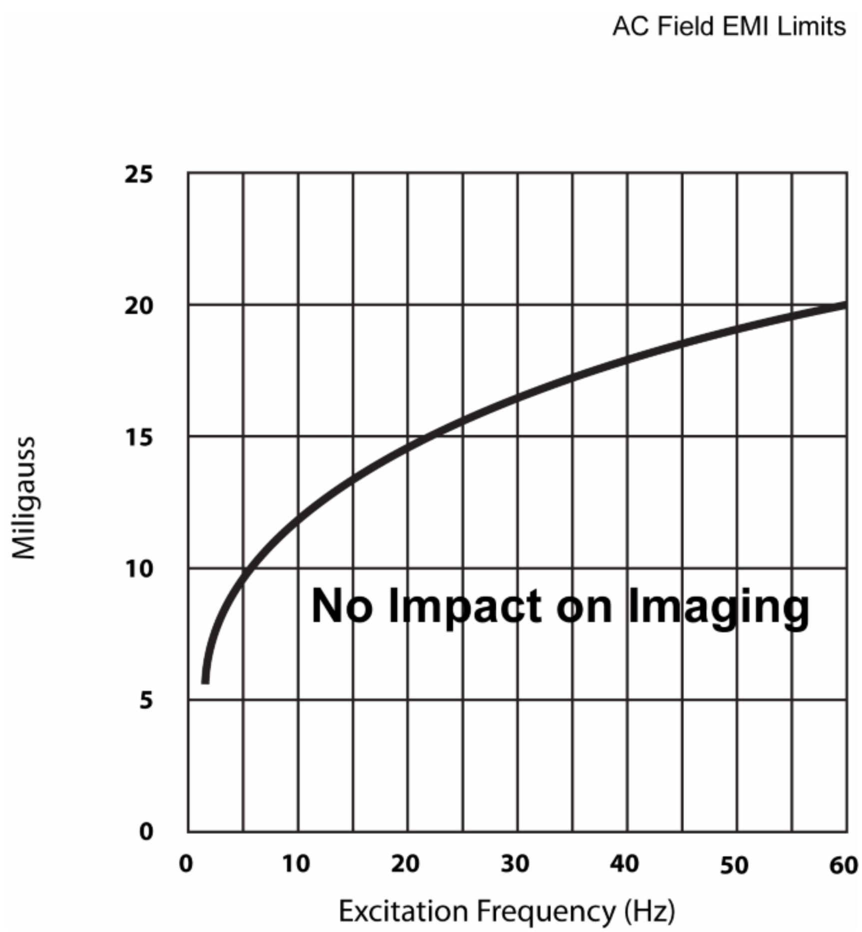
Illustration 2-9: Actual Axial Shielding Performance



7.3 Electrical Current

1. Electrical current in high voltage power lines, transformers, motors, or generators near the magnet may affect magnetic field homogeneity
2. Magnetic field interference at 50 or 60 Hz must not exceed 40 milligauss RMS respectively at the magnet location (refer to Illustration 2-10)
3. The following equation can be used as a general guide in determining allowable current in feeder lines at a given distance from the magnet isocenter:
   a. For 1.5T Magnet: $I= (20X^2)/S$
   b. I = Maximum allowable RMS single phase current (in amps) or maximum allowable RMS line current (in amps) in three phase feeder lines
   c. S = Separation (in meters) between single phase conductors or greatest separation between three phase conductors
   d. X = Minimum distance (in meters) from the feeder lines to isocenter of the magnet

Illustration 2-10: Magnet Allowable Milligauss vs. Line Frequency for AC Equipment



Refer to Chapter 7, Sample Calculation AC Power Equipment Minimum Distance for additional examples.

7.4 Non-MR System Equipment Sensitivity to Magnetic Fields

This section lists equipment known to be sensitive to high magnetic fields. Recommended limits given are based on general MR site planning guidelines. Actual susceptibility of specific devices may vary significantly depending on electrical design, orientation of the device relative to the magnetic field, and the degree of interference considered unacceptable.

The table is provided as a guide only. Actual Gauss limits are equipment specific (refer to the OEM manuals). Site plans must include consideration for magnetic field interaction with customer equipment.

NOTE: Gauss limits for MR system equipment is provided with the specifications for each component.

Table 2-6: Magnetic Proximity Limits

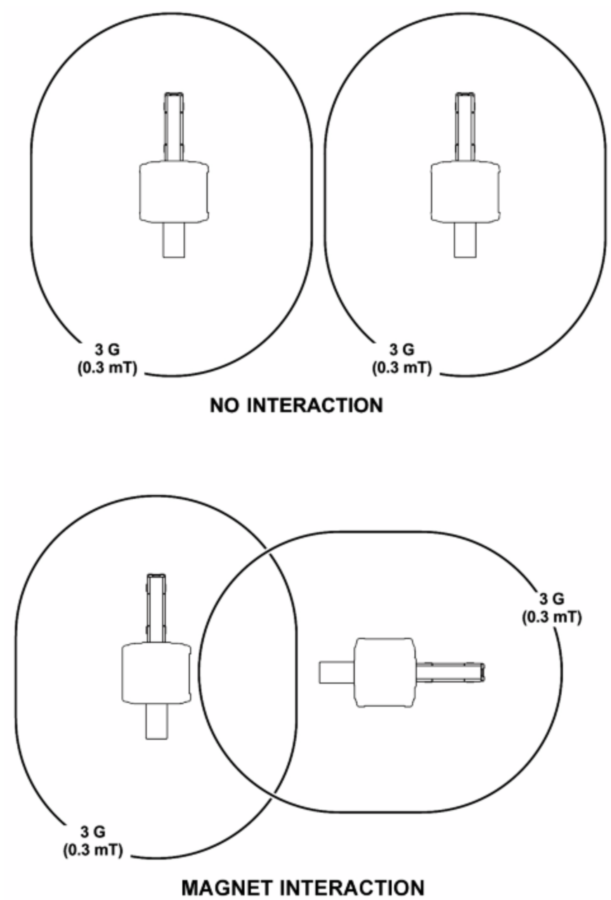
Gauss (mT) Limit	Equipment	
0.5 gauss (0.05mT)	Nuclear camera	
1 gauss (0.1mT)	Positron Emission Tomography scanner	Video display (tube)
	Linear Accelerator	CT scanner
	Cyclotrons	Ultrasound
	Accurate measuring scale	Lithotriptor
	Image intensifiers	Electron microscope
	Bone Densitometers	
3 gauss (0.3mT)	Power transformers	Main electrical distribution transformers
5 gauss (0.5mT)	Cardiac pacemakers	Biostimulation devices
	Neurostimulators	
10 gauss (1mT)	Magnetic computer media	Telephone switching stations
	Hard copy imagers	Water cooling equipment
	Line printers	HVAC equipment
	Video Cassette Recorder (VCR)	Major mechanical equipment room
	Film processor	Credit cards, watches, and clocks
	X-ray tubes	
	Large steel equipment, including:	
	Emergency generators	Air conditioning equipment
	Commercial laundry equipment	Fuel storage tanks
	Food preparation area	Motors greater than 5 horsepower
50 gauss (5mT)	Metal detector for screening	Telephones
	LCD panels	
No Limit	Digital Detectors	

8 Multiple MR System Requirements

8.1 Multiple Magnets

When installing multiple magnets, the 3 gauss lines must not intersect or the magnets will be interactive. Contact the GE Healthcare Project Manager of Installation (PMI) for any questions regarding magnetic field interaction.

Illustration 2-11: Two Magnet Installation



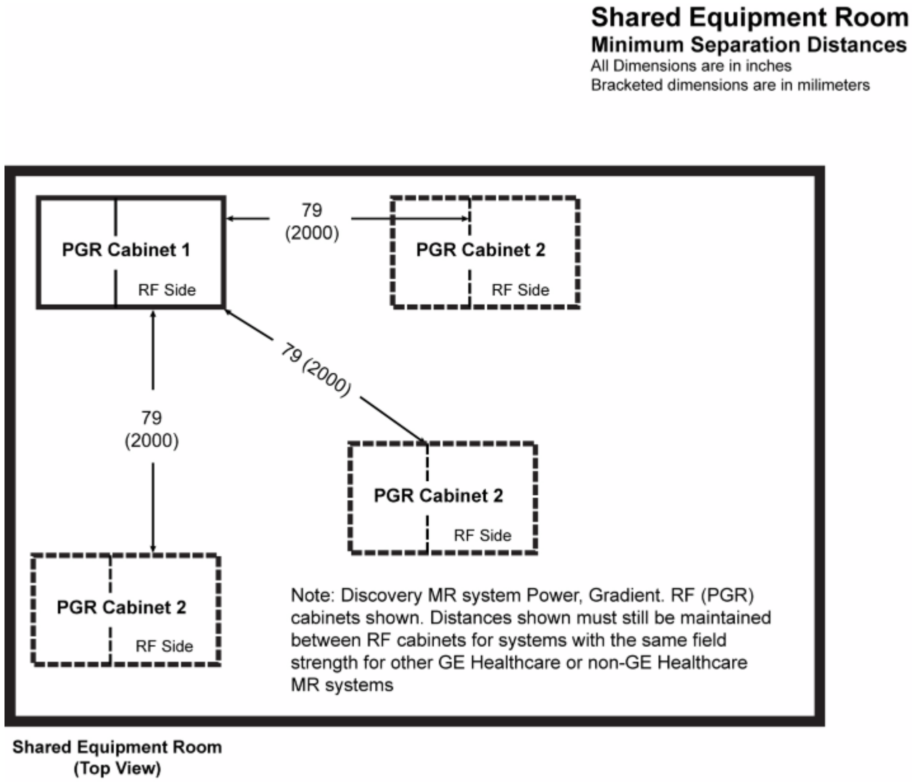
8.2 Shared Equipment Rooms

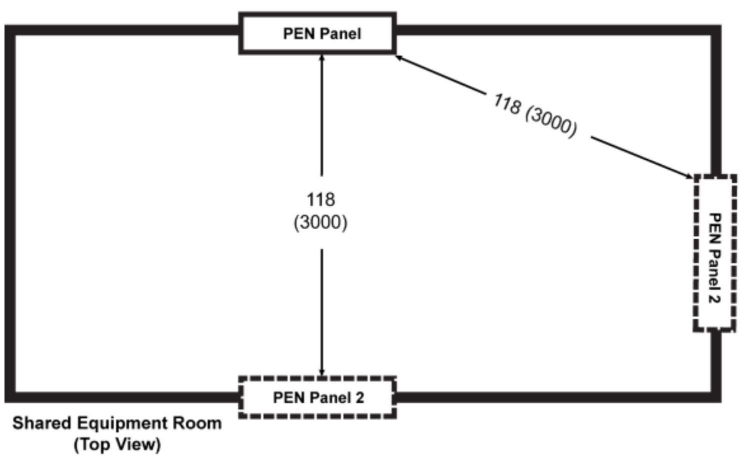
When installing multiple MR systems in a shared equipment room, the following conditions must be met:

1. RF cabinets must be separated by at least 79 in. (2000 mm)

   Refer to Illustration 2-12 for cabinet location examples.
2. Cables from different MR systems must not be routed together
3. Penetration panels must be separated by at least 118 in (3000 mm)

Illustration 2-12: Equipment Room Cabinet Separations





9 MR Suite Temperature and Humidity

CAUTION

Equipment Failure

Failure to maintain the required temperature or humidity at all times (i.e., both working and non-working hours) may result in equipment failure, scanning failure, or warranty void.

Ensure the HVAC system has the correct capacity for the room size, equipment heat output, and environmental conditions to maintain proper temperature and humidity.

This section provides temperature and humidity requirements for the MR suite. Specific construction requirements for each room can be found in the following sections:

- Magnet Room
- Equipment Room
- Control Room

9.1 Temperature and Humidity Requirements

Table 2-7: Room Temperature and Humidity Requirements

Room	Temperature		Humidity	
	Range °F (°C)	Change °F/Hr (°C/Hr)[1]	Range %RH	Change %RH/Hr[2]
Equipment Room (at Inlet to Equipment)	59-89.6 (15-32)[3]	5 (3)	30-70	5
Magnet Room	59-69.8 (15-21)	5 (3)	30-60	5
Operator Room	59-89.6 (15-32)	5 (3)	30-70	5

Notes:
1. Operating temperature gradient limits shall be between -5° F/Hr (-3° C/Hr) and 5° F/Hr (3° C/Hr), when averaged over 1 hour
2. Operating humidity gradient limits shall be between -5% RH/hour and 5% RH/hour, when averaged over 1 hour
3. Maximum ambient temperature is derated by 1 degree C per 300 m above 2000 m

1. The customer is responsible for HVAC system design, purchase, and installation
2. The temperature requirements must not be exceeded at any point during the day (both working or non-working hours)
3. A separate thermostat must be provided for the Magnet room

9.2 Equipment Heat Output Specifications

This section details the heat output for specific components. These heat outputs define the minimum, maximum and an assumed average condition. Actual heat output and room temperature may vary due to environmental factors, room insulation, actual usage, and any non-GE Healthcare equipment used in the MR suite. Also, due to large variations in heat loads, the HVAC system may require unloaders, hot gas bypass, and reheat to maintain humidity levels.

NOTE: Air cooling load for components in the Equipment room is averaged over a 12 hour working day is approximately 1/2 of the maximum value.

Table 2-8: System Heat Output for Air Cooling

Component	Magnet Room BTU/hr (W)			Equipment Room BTU/hr (W)			Control Room BTU/hr (W)		
	Maximum	Average	Idle	Maximum	Average	Idle	Maximum	Average	Idle
Magnet (MAG) and Patient Transport Table (PT)	8,189 (2,400)	4,095 (1,200)	1,915 (561)						
Blower Box	1,535 (450)	1,535 (450)	1,535 (450)						
Penetration Panel Cabinet (PEN)	1,024 (300)	512 (150)	0	10,697 (3,135)	5,349 (1,568)	5,349 (1,568)			
Secondary Penetration Wall (SPW)	0			0					
Main Disconnect Panel (MDP)				901 (264)	450 (132)	450 (132)			
Power, Gradient, RF Cabinet (PGR)				20,940 (6,137)	10,470 (3,068)	8,530 (2500)			
Cryocooler Compressor (CRY)				1,706 (500)	1,706 (500)	1,706 (500)			
Heat Exchanger Cabinet (HEC)				3,412 (1,000)	1,706 (500)	1,706 (500)			
Magnet Monitor (MON)				819 (240)	819 (240)	819 (240)			
Operator Workspace equipment (OW)							4,947 (1,450)		

Table 2-9: System Options Heat Output for Air Cooling

Component	Magnet Room BTU/hr (W)			Equipment Room BTU/hr (W)			Control Room BTU/hr (W)		
	Maximum	Average	Idle	Maximum	Average	Idle	Maximum	Average	Idle
BrainWave HW Lite Cabinet (BW)				2337 (685) base (2781 (815) with options)					
CADstream				Contact PMI					
MR Elastography				480					

10 Facility Coolant Requirements

NOTICE

Equipment Failure. A continuous supply of facility liquid coolant to the Heat Exchanger Cabinet (HEC) is required at all times for proper system operation. Failure to provide liquid coolant with the requirements listed in this section may cause equipment failure.

10.1 Heat Exchanger Cabinet (HEC) Coolant Requirements

1. The facility must provide liquid coolant to the Heat Exchanger Cabinet (HEC)
2. The facility must provide pipe/hose, filter, and connectors to the HEC
3. The facility must provide an uninterrupted supply of liquid coolant to the HEC at magnet delivery
4. The vertical distance between the coolant connection points of the HEC and the Gradient Coil must be less than 196.8 in. (5 meters)
5. The customer must provide and install an in-line flow meter on either the supply or return facility coolant hose. The flow meter must be capable of visually displaying volumetric flow between 20 and 50 gpm (76 and 189 L/min) and configured for the properties of the cooling fluid in use

Table 2-10: Facility Liquid Coolant Requirements

Parameter	Requirements
Availability	Continuous
Antifreeze	0-40% propylene glycol
Minimum Flow	30 gpm (114 L/min)
Maximum Flow	35 gpm (132 L/min)
Maximum Pressure Drop in HEC at Minimum Flow	34.8 psi (2.4 bar) with 40% propylene glycol-water; 1021 kg/m^3 density
Maximum Pressure Drop in HEC at Maximum Flow	47.8 psi (3.3 bar) with 40% propylene glycol-water; 1021 kg/m^3 density
Temperature rise at Minimum Flow	12.2°F (6.8°C) with 40% propylene glycol-water; 3730 J/(kg K) specific heat;1021 kg/m^3 density; 49 kW heat
Temperature rise at Maximum Flow	10.4°F (5.8°C) with 40% propylene glycol-water; 3730 J/(kg K) specific heat; 1021 kg/m^3 density; 49 kW heat
Maximum Inlet Pressure to HEC	87 psi (6 bar)
Chiller Size	Minimum 49 KW
Condensation Protection	Facility Plumbing to the HEC must be properly routed and insulated to prevent equipment damage or safety hazards
Minimum Continuous Heat Load	7.5 KW
Inlet Temperature	44.6 to 50°F (7 to 10°C) measured at the inlet to the HEC
Customer supplied feeder hose (from main water supply to HEC)	1.5 inch (38.1 mm) minimum hose inside diameter
Hose connections to the HEC	1.5 inch (38.1 mm) male NPT

Illustration 2-13: Allowable Facility Water Temperature and Flow

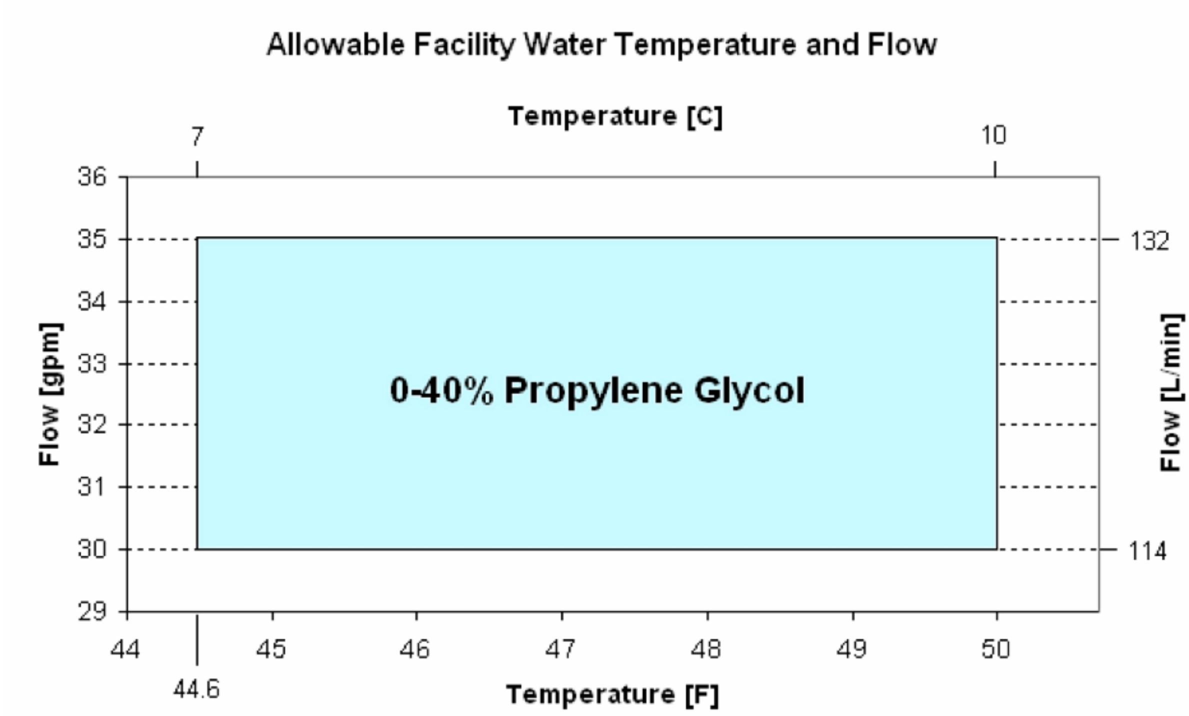


Illustration 2-14: Pressure Drop through HEC

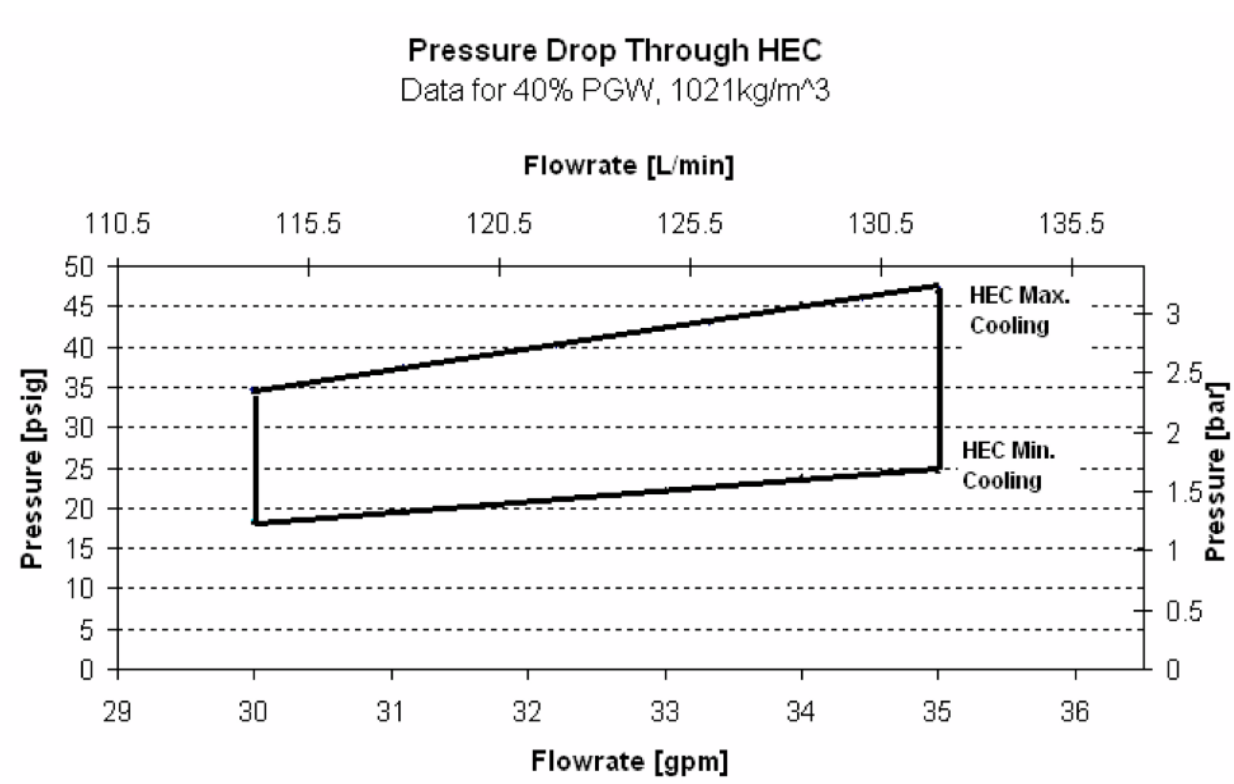


Illustration 2-15: Temperature Rise through HEC (40% PGW)

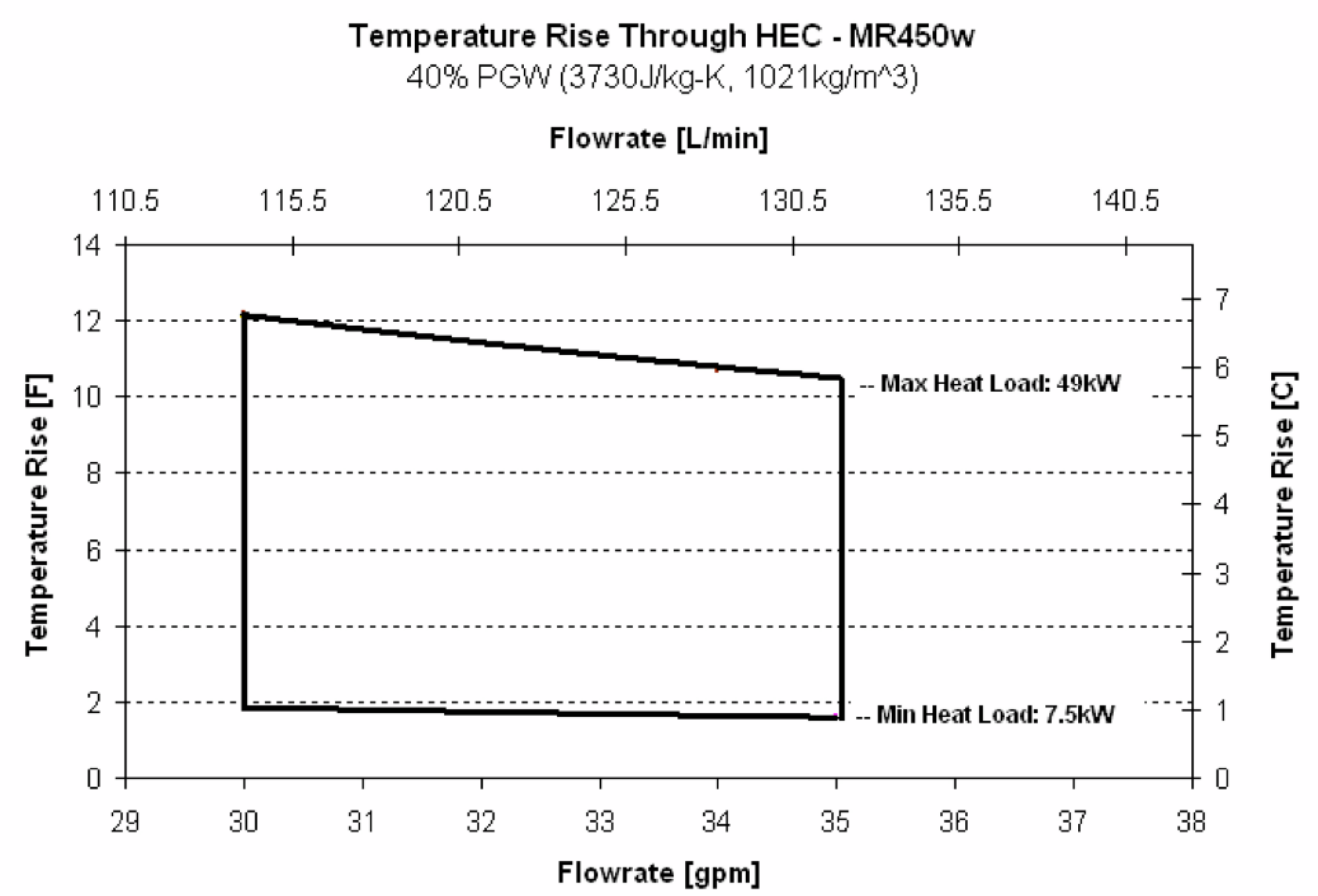


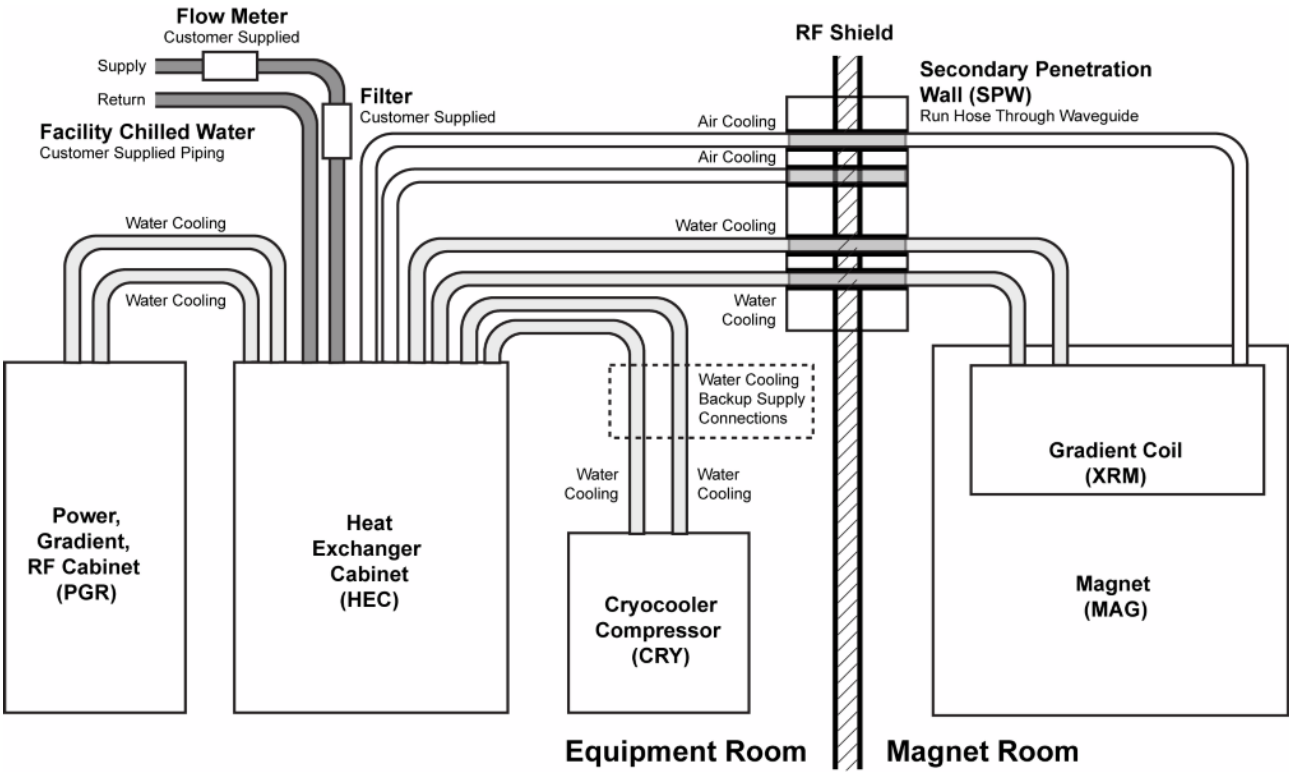
Illustration 2-16: Temperature Rise through HEC (0% PGW)

Table 2-11: Water Quality

pH Value	6.5 to 8.2 at 77 °F (25 °C)
Electrical Conductivity	< 0.8 mmho/cm
Chloride Ion	< 200 ppm
Sulfate Ion	< 200 ppm
M-Alkalinity	< 100 ppm
Total Hardness	< 200 ppm
Calcium Hardness	< 150 ppm
Ionic Silica	< 50 ppm
Iron	< 1.0 ppm
Copper	< 0.3 ppm
Sulfide Ion	None, not detectable
Ammonium Ion	< 1.0 ppm
Residual Chlorine	< 0.3 ppm
Free Carbon Dioxide	< 4.0 ppm

Stability Index	6.0 to 7.0
Suspended Matter	< 10 ppm
Particle Size	< 100 micron (with field changeable filter)

Illustration 2-17: MR System Water Cooling Block Diagram



10.2 Emergency Facility Coolant Requirements

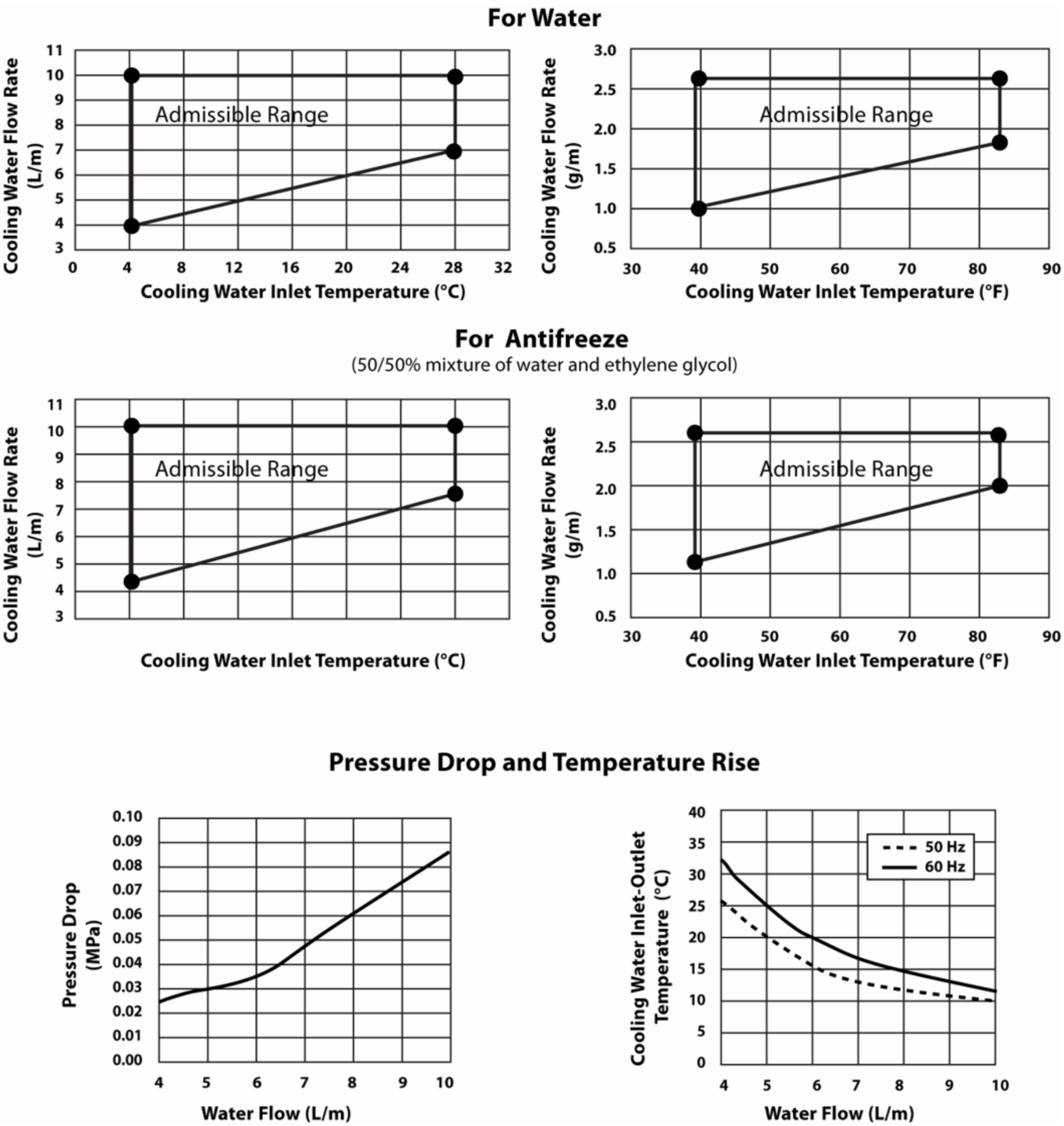
The facility may provide an optional backup coolant supply in one of the following configurations:

1. Full system functionality: Backup coolant is routed through the HEC and meets all HEC coolant requirements above
2. Cryocooler operation only: Backup coolant is routed through the HEC and meets all HEC coolant requirements except temperature. Temperature must meet the requirements listed in Illustration 2-18. (Note: Full HEC flow requirements must still be met. The HEC will split off 6 L/min to the cryocooler compressor)
3. Cryocooler operation only: Coolant may be routed directly to the Cryocooler compressor at the location indicated in Illustration 2-17 with the following requirements:
    a. The facility is responsible for coolant, pipe/hose, filters, and connectors to supply the coolant to the CRY
    b. The emergency coolant supply must isolate the Cryocooler Compressor and not back-feed the HEC
    c. Coolant must meet all other HEC coolant specifications listed in Table 2-10 and Table 2-11

d. The supplied water cooling hoses between the HEC and CRY are Parker Push-lok 801-8, 0.5 in. I.D.

e. The charts below shows the coolant flow rate and temperature requirements for the Cryocooler Compressor:

Illustration 2-18: Cryocooler Water Cooling requirements for Emergency Water Supply



11 MR Suite Electrical Requirements

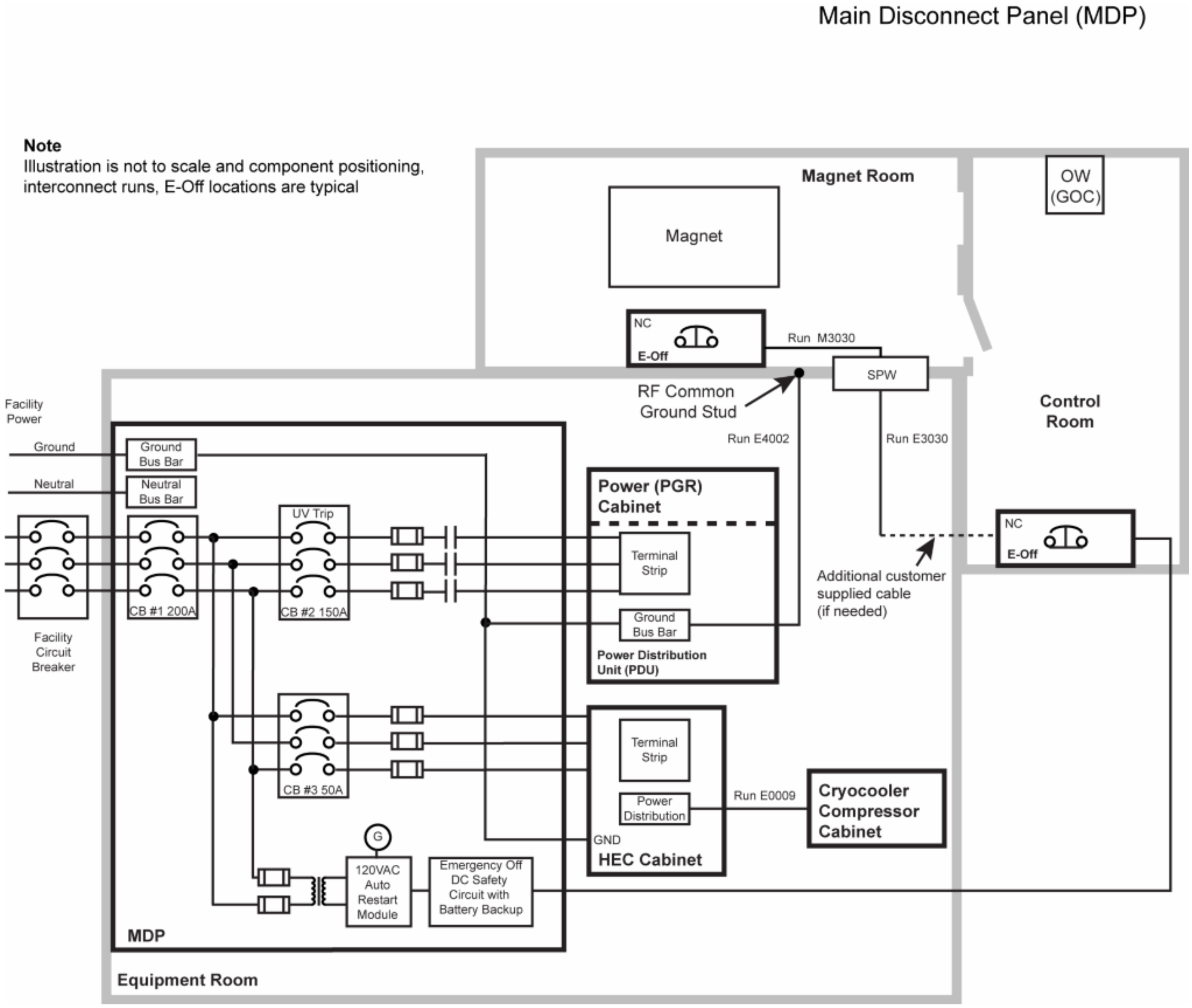
1. An MDP is provided with the system and is delivered prior to system delivery
2. The facility must provide system power and cabling to the Main Disconnect Panel (MDP)
3. All associated transformers and cables must be correctly sized for system power requirements
4. Facility power is required at magnet delivery and must be available continuously thereafter

Table 2-12: Facility Power Requirements

Component	Parameter	Requirements	
At Main Disconnect Panel (MDP)	Voltage / Frequency	480 VAC	60 ± 3 Hz
		415 VAC	50 ± 3 Hz
		400 VAC	50 ± 3 Hz
		380 VAC	50 ± 3 Hz
	Daily Voltage Variation	± 10% from nominal under worst-case line and load regulation	
	Voltage Transients	Maximum allowable transient voltage above or below nominal waveshape not to exceed 200 V at a maximum duration of 1 cycle and frequency of 10 times per hour.	
	Phase	Input power to the MDP may use one of the following configurations: • A 3 phase solidly grounded WYE with Neutral and Ground (5-wire system). Neutral must be terminated prior to or inside the Main Disconnect Panel and not brought to the Power, Gradient, Reconstruction cabinet (PGR) or the Heat Exchanger Cabinet (HEC). • A 3 phase DELTA with Ground (4-wire).	
	Phase Balance	Difference between the highest phase line-to-line voltage and the lowest phase line-to-line voltage must not exceed 2%	
	Regulation	2% maximum at system maximum power demand (averaged over 5 seconds) from source to PDU input (i.e. includes all feeders and transformer to utility)	
	Facility Zero Voltage Reference Ground	• The facility ground for the MR system must originate at the system power source (i.e., transformer or first access point of power into the facility) and be continuous to the MR system Main Disconnect Panel (MDP) in the room. • Main facility ground conductor to Main Disconnect Panel (MDP) must be appropriately sized insulated copper wire. • Ground impedance to earth at power source to be 2 ohms or less.	
	Power Demand	Maximum Momentary	123 kVA for 5 sec consisting of 103 kVA for PDU and 20 kVA for HEC
		Maximum Continuous (while scanning)	99 kVA consisting of 79 kVA for PDU and 20 kVA for HEC
		Standby (no scan)	No more than 17 kVA
	Power Availability	Continuous. Facility power is required at all times for operation of the Heat Exchanger Cabinet (HEC) and Cryocooler (CRY).	
	MDP Circuit Breaker	CB#1: 200 Amps, CB#2: 150 Amps, CB#3: 50 Amps	
	MDP Short Circuit Current Rating	25,000 Amps	

<table>
<tr><th>Component</th><th>Parameter</th><th colspan="2">Requirements</th></tr>
<tr><td rowspan="6"></td><td rowspan="6">Facility Supplied Wiring</td><td colspan="2">Facility supplied wiring is required for facility input power to MDP, from MDP to PGR, and from MDP to HEC.</td></tr>
<tr><td>MDP phase input CB#1</td><td>Accommodates 3/0 AWG maximum wire size</td></tr>
<tr><td>MDP Input Ground/PE terminal</td><td>8AWG to 350KCMIL</td></tr>
<tr><td>MDP Input Neutral Terminal</td><td>Accommodates 3/0 AWG maximum wire size</td></tr>
<tr><td>PGR Input phase & ground</td><td>1/0 AWG wire size</td></tr>
<tr><td>HEC Input phase & ground</td><td>8 AWG wire size (or equivalent). Provided strain relief accepts non-metallic jacketed cord with outside diameter range: 0.875 in. (22.0 mm) min. to 1.26 in. (32.0 mm) max.</td></tr>
<tr><td>Emergency Off Buttons</td><td colspan="3">Two Remote flush wall mounted E-Off buttons are supplied with the MDP. E-Off buttons and associated wiring are located per customer requirements.</td></tr>
<tr><td rowspan="3">Service receptacle in Magnet Room</td><td>Voltage / Frequency</td><td>100-120 VAC 50/60 Hz</td><td rowspan="3">Receptacle required for small power tools. Local voltage and portable transformers for voltage values.</td></tr>
<tr><td>Phase</td><td>1</td></tr>
<tr><td>Maximum Amps</td><td>2.0</td></tr>
</table>

Illustration 2-19: MR System Main Disconnect Panel (MDP) Set-Up



12 MR System Shipping and Receiving

NOTICE

All shipping dimensions and weights are approximate and may vary based on ship-to location, required rigging, or other requirements. Some shipping or access routes may have requirements in addition to those listed in this section. Contact the GE Healthcare Project Manager of Installation (PMI) to verify magnet shipping, rigging, and access.

12.1 Receiving Requirements

1. The customer must provide an area for unloading system components from the truck and delivering to the MR suite

   NOTE: Contact the GE Healthcare Project Manager of Installation (PMI) for a list of experienced rigging companies.

2. The customer is responsible for ensuring:

   a. All floors along the route will support the weight of the magnet (GE Healthcare recommends a structural analysis)

   b. Doors or other openings are sufficiently wide to allow passage

   c. Sufficient room is provided for any required dollies or rigging

12.2 Facility Delivery Route Requirements

The following table lists the delivery dimensions of system components. The delivery route must be planned to accommodate the dimensions listed.

Table 2-13: Delivery Route Requirements

Component	Width		Depth		Height		Weight		Comments
	in	mm	in	mm	in	mm	lbs	kg	
Magnet	See Magnet shipping dimensions Table 2-14								
Cryogen	Dimensions vary depending on dewar type used. Verify with cryogen supplier.								
PGR Cabinet	78.75	2000	34.3	872	83	2108	3459	1115	Cabinets are moved with dollies attached to each side (adding 20 in. (520 mm) to the width and 180 lbs (82 kg) to the weight). Cabinets must be raised to remove the pallet but may be lowered almost to floor level while moving.
HEC Cabinet	55.2	1400	34.3	872	75	1900	1130	513	
PEN Cabinet	44.1	1120	39.4	1000	76	1930	819	371	

12.3 MR System Component Shipping Specifications

MR system component shipping dimensions and weight are listed below:

Table 2-14: MR System Component Shipping Specifications

MR Component	Approximate W x D x H		Approximate Weight		Method Of Shipment
	in.	mm	lbs	kg	
Magnet as shipped (with lifting bars)	93 x 144 x 107	2362 x 3658 x 2718	Domestic: 11,735 International: Add 2,200 for Crating	Domestic: 5322 International: Add 998 for Crating	Domestic: Tarped. International: Crate/Pallet
Magnet Accessory Equipment	48 x 48 x 28	1219 x 1219 x 711	400	182	Crate
Cryocooler Compressor	26 x 28 x 42	660 x 711 x 1067	275	125	Pallet with box cover
Rear Pedestal Assembly with Rear Split Bridge Assembly, Low Profile Carriage Cover	34 x 58 x 48	864 x 1473 x 1219	310	132	Box on pallet
Enclosure Top	48 x 36 x 36	1219 x 914 x 914	30	14	Box
Enclosure Skirts	40 x 24 x 24	1016 x 610 x 610	30	14	Box
Patient Table	94 x 29 x 38	2377 x 722 x 952	618	280	Pallet
Power Gradient RF Cabinet (PGR) (Domestic)	67.25 x 41 x 88	1708 x 1041 x 2235	3654	1657	Pallet
Power Gradient RF Cabinet (PGR) (International)	68.25 x 42 x 92	1734 x 1067 x 2337	3654	1657	Pallet
Penetration Panel Cabinet (PEN) (Domestic)	43.75 x 35.25 x 80.75	1111 x 895 x 2051	710	322	Pallet
Penetration Panel Cabinet (PEN) (International)	44.75 x 35.25 x 84.75	1137 x 895 x 2153	770	350	Pallet
Heat Exchanger Cabinet (HEC) (Domestic)	45 x 44.75 x 80	1143 x 1137 x 2032	1075	488	Pallet
Heat Exchanger Cabinet (HEC) (International)	46 x 45.75 x 84	1168 x 1162 x 2134	1150	522	Pallet
Secondary Penetration Wall	21 x 24 x 64	533 x 610 x 1626	101	45	Pallet with cardboard cover
SPT Phantom Set	34 x 32.5 x 60	864 x 826 x 1524	350	159	On cart casters with box cover
Operator Workspace Cabinet	24 x 35 x 31	600 x 900 x 780	243	110	Wood pallet with cardboard cover
Operator Workspace Display	27 x 33 x 27	686 x 838 x 686	125	57	Pallet
Operator Workspace equipment	32 x 32 x 23	813 x 813 x 584	100	45	Box
Operator Workspace Table	45 x 54 x 37	1143 x 1372 x 940	180	82	Box

Table 2-15: MR System Optional Component Shipping Specifications

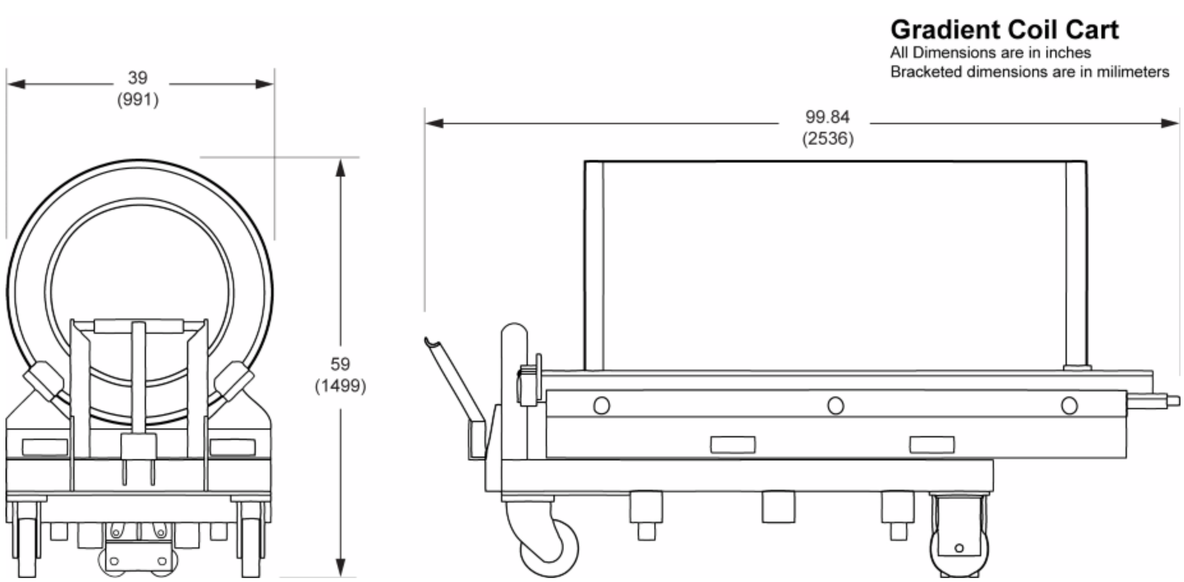
BrainWaveHW Lite Cabinet	24 x 23 x 72	610 x 584 x 320	320	147	On cabinet casters, wrapped with plastic
VibroAcoustic Damping Option	36 x 65 x 12	914 x 1651 x 305	575	261	Box on pallet

Table 2-16: MR System Component Replacement Shipping Specifications

Component	Approximate Weight lbs (kg)	Overall Dimensions W x D x H in. (mm)	Comments
Split Bridge	40 (18)	21.5 x 77.3 x 7 (546 x 1969 x 177.8)	
Replacement RF Body Coil	155 (70)	30 x 30 x 60 (762 x 762 x 1524)	Replacement coil is shipped in a protective case. Weight & dimensions are for coil & case.
Replacement XRM Gradient Coil Assembly on a Shipping Cradle/ Cart	3194 (1449)	39 x 99.84 x 59 (991 x 2536 x 1499) See Note	Initial Gradient Coil Assembly is shipped installed in the Magnet. Shipping/installation cart is used to install replacement coil assembly only.
Gradient Coil Replacement Tool Kit Crate	750 (340)	30 x 86 x 28 (762 x 2184 x 711)	Gradient Coil Assembly and shipping cart dimensions are with cart in lowest position. Cart can be adjusted to maximum height of 61.88 in. (1572 mm).

Note:
The replacement Gradient Coil Assembly weight is approximately 2205 lbs (1000 kg), the shipping cradle is 132 lbs (60 kg), and the Gradient Coil Assembly shipping/installation cart weighs 855 lbs (389 kg). The coil assembly outside diameter x length dimensions are 35.7 x 57.2 in. (908 x 1452 mm).

Illustration 2-20: Gradient Coil Cart



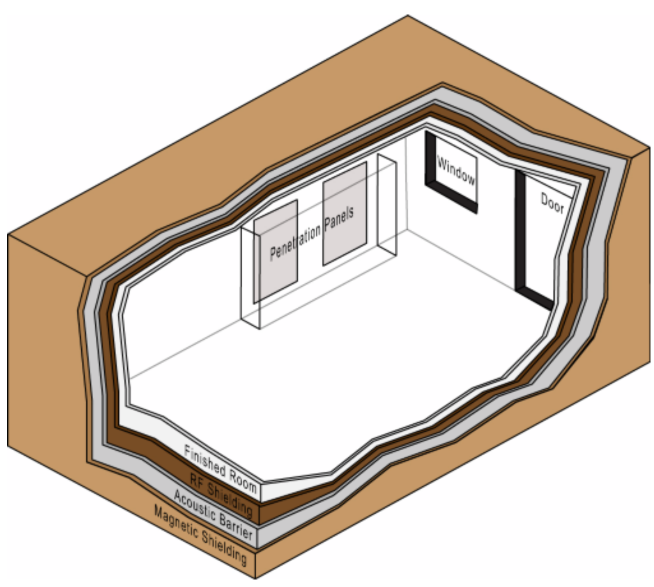
Chapter 3 Magnet Room

1 Magnet Room Introduction

The Magnet Room is best understood as a series of layers, or “rooms within a room.” Each of these rooms has a specific function and associated requirements. All requirements in this chapter must be followed to ensure safe and proper operation of the MR system.

1. The Magnetic shielded room contains the MR Magnet fringe field within a confined space. A site survey is required to determine magnet shield requirements (not all sites require magnetic shielding). Because of the added cost of magnetic shielding, room location should be carefully considered.
2. The Acoustic room is a layer used to help attenuate the noise produced during a scan. An acoustic engineer is strongly recommended to assess the environment.
3. The RF Shielded room is critical to the proper MR system operation. RF shielding prevents interaction of external RF radiation with MR system operation and it also prevents MR system RF radiation from interfering with external systems, such as aircraft control). Special care must be used when installing all fixtures penetrating the RF shield (e.g., vents, electrical conduit, penetration panels) to ensure the integrity of the RF shield is maintained.
4. The Finished room includes the wall coverings, ceiling tile, ceiling grid, other fixtures, Magnet (MAG) and Patient Table (PT). When planning the finished room, ensure the following:
    a. All building codes are met (such as maintaining egress routes)
    b. Items which may cause RF interference (such as fluorescent lighting) are not used
    c. Ferrous or metallic items which could become projectiles when the magnet is installed (including wall coverings, ceiling tile, ceiling grid, or other fixtures) are not used or properly secured

Illustration 3-1: Magnet Room Layers



2 Magnet Room Structural Requirements

This section lists the structural requirements that must be considered when performing site evaluation and planning of the Magnet room.

2.1 Overview

1. When preparing a building plan or evaluating a potential site for an MR system, care should be taken to so the MR suite will not interact with the surrounding environment (i.e., magnetic, acoustic and vibration)
2. The customer is responsible for vibration testing required to verify suitability of a proposed site. All test results and any questions regarding testing, results, or analysis must be forwarded to the GE Healthcare Project Manager of Installation (PMI)

2.2 Environmental Steel Limits

A static magnetic field extends in a three-dimensional space around the magnet isocenter. Environmental steel within the static magnetic field affects the uniformity (or homogeneity) of the field. Field uniformity is critical to both image quality and chemical shift analysis (spectroscopy). An analysis of the environmental steel is required in within a 9.84 feet (3 meters) spherical radius of the magnet isocenter. Environmental steel includes pipes, beams, concrete rebar, or any other structural steel in the floors, walls, or ceiling.

The following items must be limited perTable 3-1.

1. Non-movable steel construction material such as wall studs or HVAC components
2. Metallic pipes and drains
3. Steel in the floor in a 10 ft x 10 ft (3.1 m x 3.1 m) area under the Magnet (MAG)

Table 3-1: Steel Mass Limits to Magnet Isocenter (10 x 10 Area Under Magnet)

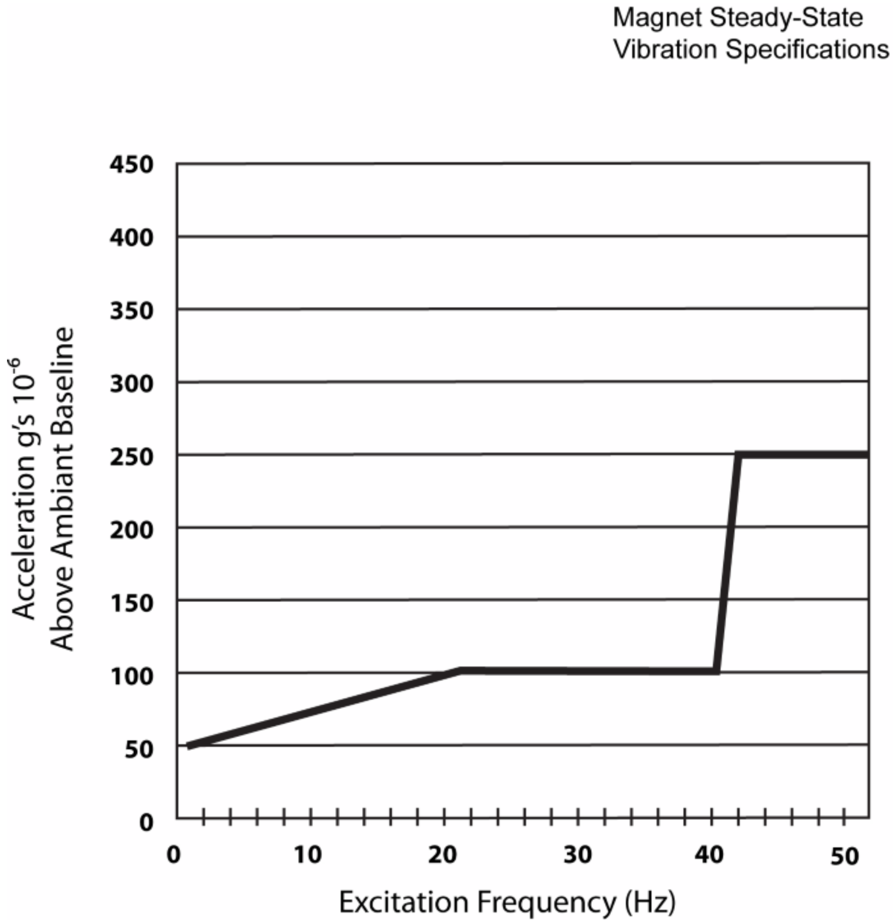
Limits Of Steel Mass lbs/ft^2 (kg/m^2)	Distance From Magnet Isocenter in. (mm)	Distance Below Top Surface Of Floor in. (mm)
0 (0)	0-45 (0-1143)	0-3 (0-76)
2 (9.8)	45-47 (1143-1194)	3-5 (76-127)
3 (14.7)	47-52 (1194-1321)	5-10 (127-254)
8 (39.2)	52-55 (1321-1397)	10-13 (254-330)
20 (98.0)	55+ (1397+)	13+ (330+)

2.3 Vibration Requirements

Excessive vibration can affect MR image quality. Vibration testing must be performed early in the site planning process to ensure vibration is minimized. Both steady state vibration (exhaust fans, air conditioners, pumps, etc.) and transient vibrations (traffic, pedestrians, door slamming, etc.) must be assessed. Specific requirements for vibration mitigation, include:

1. The Magnet (MAG) cannot be directly isolated from vibration. Any vibration issue must be resolved at the source
2. MR Suite HVAC must have vibration isolation
3. A vibration analysis must be performed at the proposed site with the results (and any mitigation) forwarded to the GE Healthcare Project Manager of Installation (PMI). See the Chapter 7, MR Site Vibration Test Guidelines
4. A transient vibration test must only be performed after a steady-state test has been performed and all steady-state sources of vibration have been mitigated
5. Transient vibration levels above the specified limits in the Chapter 7, MR Site Vibration Test Guidelines must be analyzed
6. Any transient vibration that causes vibration to exceed the steady-state level must be mitigated

Illustration 3-2: Magnet Steady State Vibration Specifications



3 Magnetic Shielded Room Requirements

NOTICE

All sites, including upgrade sites, must be evaluated for magnetic shielding requirements. Existing magnetic shielding at an upgrade site may not be sufficient for the new system. Contact the GE Healthcare Project Manager of Installation (PMI) to request a site evaluation.

Magnetic shielding prevents interaction between the magnet and nearby sensitive devices. Because of the added cost of magnetic shielding, room location should be carefully considered (not all sites require magnetic shielding). See Chapter 2, MR Suite Magnetic Field Specifications for detailed magnetic proximity limit information.

1. The GE Healthcare Project Manager of Installation (PMI) works with the customer to coordinate the magnetic shielding site evaluation
2. If required, the GE Healthcare Project Manager of Installation (PMI) coordinates the delivery of the magnetic shielding design
3. The customer is responsible for installation of all magnetic shielding

4 Acoustic Room Specifications

The Acoustic room is a layer used to help contain the noise produced during a scan. The following information is provided as a guide for the acoustic engineer to design acoustic noise containment in the Magnet room.

Table 3-2: Acoustic Specifications

	Maximum Sound Pressure Level for Room Design	Frequency
Magnet Room	127 dBA	20 to 20k Hz
Note: Hearing protection must be provided to the patient to reduce the sound pressure level below 99 dBA.		

Refer to Chapter 7, Acoustic Background and Design Guidelines for acoustic design information.

5 RF Shielded Room Requirements

The RF Shielded room is critical to the proper MR system operation. RF shielding reduces the interaction of external RF electromagnetic fields with MR system operation (it also prevents MR system RF radiation from interfering with external RF systems, such as aircraft control). Special care must be used when installing all fixtures penetrating the RF shield (e.g., vents, electrical conduit, penetration panels, etc.) to ensure the integrity of the RF shield is maintained.

The RF shielded room can be either a free standing shielded enclosure or a shielded room within an existing room.

5.1 RF Noise Definitions

Broadband Interference

Broadband interference is caused by electrical discharge within the Magnet room. Potential sources of interference can be reduced by limiting static discharge, ensuring all metal-to-metal contact is tight and secure, and ensuring all electrical and grounding requirements are met.

Discrete Interference

Discrete interference is fixed-frequency, narrowband RF noise. Potential sources of discrete interference are radio station transmitters and mobile RF transmitting devices. Magnet room RF shielding prevents external RF energy from entering the room and degrading the MR system RF receivers.

Electromagnetic Environment

The totality of electromagnetic phenomena existing at a given location.

Plane Wave

An electromagnetic wave which predominates in the far-field region from an antenna (or source), and with a wave front which is essentially a flat plane.

Penetration

The passage through a partition or wall of an equipment or enclosure by a wire, cable, pipe, waveguide, or other conductive object.

Shield

A housing, screen, or cover which substantially reduces the coupling of electric and magnetic fields into or out of circuits or prevents the accidental contact of objects or persons with parts or components operating at hazardous voltage levels.

Shielding Enclosure (Faraday Cage)

An area (box, room, or building) specifically designed to attenuate electromagnetic radiation, or electromagnetic radiation and acoustical emanations, originating either inside or outside the area.

Shielding Effectiveness (SE)

A measure of the reduction or attenuation in the electromagnetic field strength at a point in space caused by the insertion of a shield between the source and that point.

5.2 Ambient Radio Frequency Interference (RFI) Requirements

The MR System operates with a highly sensitive RF receiving front end to be able to capture the signal of an object scanned. The RF Shielded Room is used to provide a degree of RF isolation to reduce the interference potential from external RF electromagnetic fields. A Limited level of RF interference (RFI) at the installation site is required for the proper operation for the MR System. The RFI level will depend on the electromagnetic environment, the equipments installed or at the vicinity of the installation site, some examples are radio stations, land mobile radio transmitter stations.

1. When a RFI site survey is required, it is recommended to be completed before the purchase and installation of the RF shielded room
2. The ambient RF noise measured should be less than 100 millivolt per meter (100 dB microvolt per meter)
3. Listed in the table below are the recommended centerband and bandwidth frequencies to be used when measuring RFI. This table includes frequency bands important for both imaging and spectroscopy

Table 3-3: Radio Frequency Survey Specifications

Isotope	Bandcenter MHz	Bandwidth Hz
^{1}H	63.86	916,138
^{19}F	60.12	981,882
^{31}P	25.88	390,296
^{23}Na	16.90	242,773
^{13}C	16.06	233,925

RFI site surveys are to be performed by cycling through the preceding frequency bands and a broad band range up to 100MHz ± 10 MHz (up to 145 MHz ± 10 MHz is recommended for new sites to accommodate upgrades) . Special emphasis, however, should be placed on the 1H band since this is used in proton imaging. The RFI site survey should be performed for a length of time necessary to determine, within a reasonable degree of certainty, the maximum field strength.

To ensure that RF noise peaks outside the bandwidths specified above do not actually extend into these bandwidths and exceed the 100 millivolt per meter limit, adjust the resolution of the test equipment (spectrum analyzer) according to the equation:

$$BW\ (resolution) = f_0 /50$$

where: BW = Bandwidth (resolution)

f_0 = Center frequency (for 1H: at 1.5 Tesla 63.86 MHz)

5.3 Customer Responsibilities

1. The customer is responsible for contracting with a RF Shielding Enclosure vendor to design, install, test, the RF shielded room (including installation of dock anchor and magnet anchors, if required). On request, the GE Healthcare Project Manager of Installation (PMI) can supply a list of RF Shielding enclosure vendors

   NOTE: The RF shield may not be in a temperature or humidity controlled environment. Shielding, shield support, and associated components must be installed to prevent degradation over the life of the MR system

2. The customer is responsible for maintenance and repair of RF shielded room, to include, but not limited to, shielding effectiveness (SE) , door threshold and door seal, pressure equalization vent operation for the life of the MR System
3. All RF shield designs must be provided to the GE Healthcare Project Manager of Installation (PMI)

5.4 Requirements

5.4.1 RF Shield Requirements

1. The RF shielding must provide 100 dB (up to and including 100 MHz ± 10 MHz) planewave attenuation for the entire room including all shield penetration points. Note: 100 dB (up to and including 145 MHz ±10 MHz) is recommended for new construction to accommodate future upgrades

   NOTE: When measuring planewave attenuation in the RF shield room, Penetration Panel blanking plates must be installed.

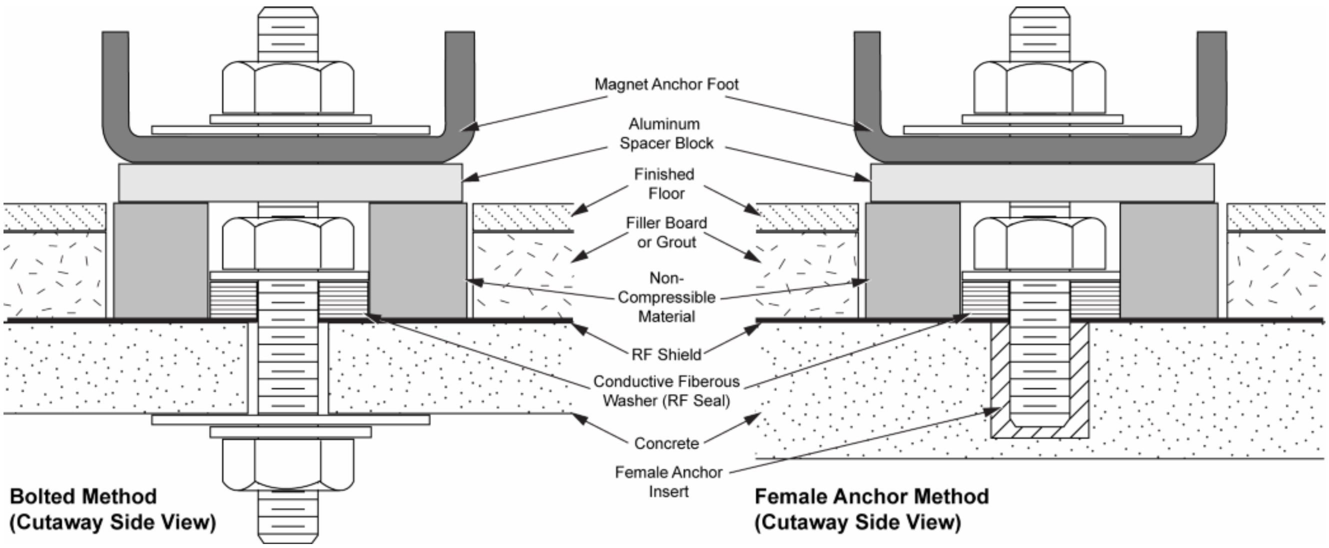
2. The RF Shield vendor installs wave guides including the Cryogen Vent. See Magnet Room Venting Requirements
3. The customer must work with the RF shielding enclosure vendor to install any waveguides for optional GE Healthcare (e.g., an MRE air hose) or Non-GE options (functional imaging signal cables)
4. The RF shielded room must be isolated from earth ground by more than 1000 ohms DC resistance during construction (before electrical installation)
5. The RF shielded room must be grounded to the RF common ground stud (which is grounded back to the Power Distribution Unit in the Power, Gradient, RF cabinet)
   a. Primary Ground: All RF Shield components (walls, floor, ceiling, etc) must be electrically bonded together to form one common ground plane which is connected to the Facility Grounding Conductor
   b. Secondary Ground (Other grounds that connect the outside of the RF Shield room to earth grounds are called secondary grounds): See Grounding Requirements for RF Shield room grounding details
6. Facility power to the Magnet room must not compromise the RF Shield primary ground
7. RF shielded room installation materials must meet steel mass limits listed in Magnet Room Structural Requirements to keep magnetic field homogeneity

8. Any moving part (such as doors) must not contain magnetic materials
9. Shielding Effectiveness (SE) and DC ground isolation resistance testing are performed by the customer with a report provided to the GE Healthcare Project Manager of Installation (PMI)

5.4.2 Magnet Mounting Requirements

The following requirements are applicable only if the VibroAcoustic dampening option is not included with the MR system.

Illustration 3-3: Magnet Anchor Mounting Options



1. The RF Shield vendor must design and install magnet anchor bolts
2. All four Magnet feet must be anchored to the floor
3. Magnet anchors must be installed before the Magnet is delivered
4. Refer to RF Shielded Room Requirements for Magnet Feet mounting hole locations
5. Magnet anchors must not contact floor rebar or other structural steel
6. Magnet anchors must electrically contact the RF shield at point of entry
7. Magnet anchors must have the following properties:
    a. Anchors must be two-part assembly (male/female)
    b. Female side must be expansion- or epoxy-type
    c. Male side must be a bolt or threaded rod with appropriate-sized nut (bolt or rod must be removable--not epoxied or cemented in place)
    d. Anchors must be electrically conductive
    e. Anchors must be non-magnetic
    f. Anchors must not induce galvanic corrosion with the RF shield
    g. Anchors must be commercially procured

h. Anchor rods diameter must be between 0.625 in (M16) and 1.25 in (M32)

i. Anchors must meet the following clamping force: 2,700 lbs (12,000 N)

j. The anchor rod must not extend less than 4.5 in. (110 mm) above the finished floor

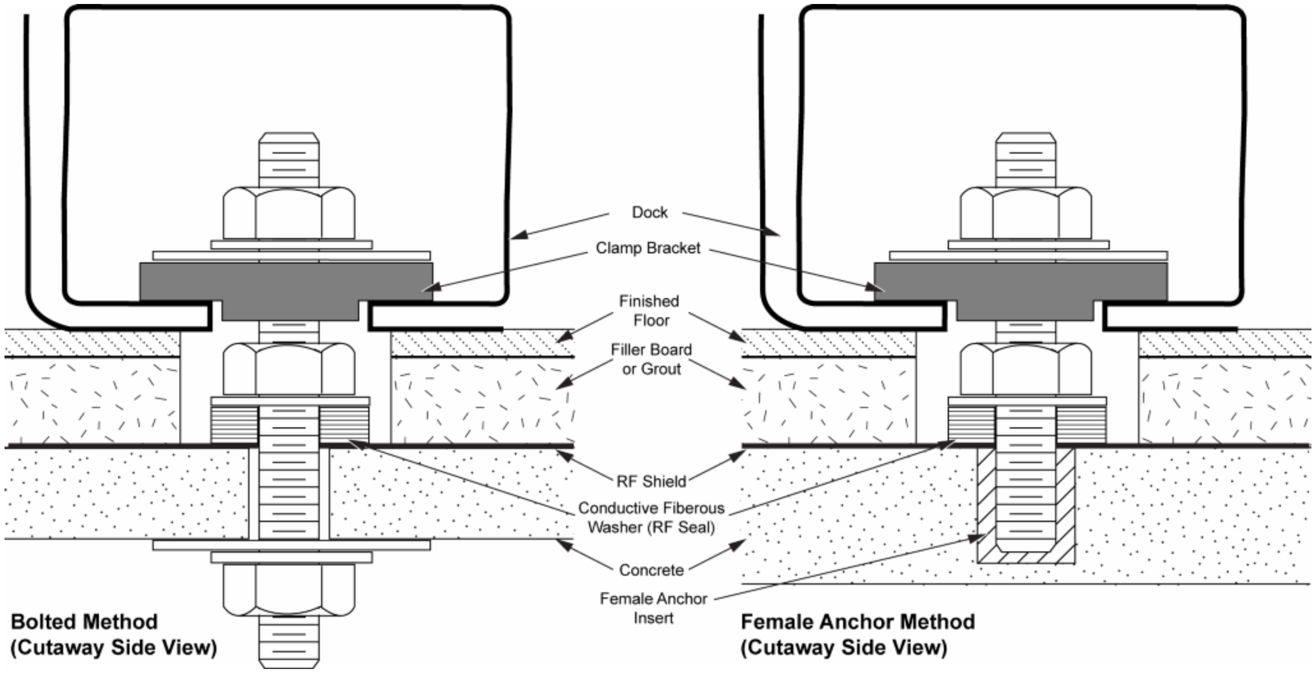
k. The anchor rod must not extend more than 5 in. (130 mm) above the finished floor

NOTE: Refer to Chapter 7, Selecting Magnet Anchor Size for an example of how to properly size the Magnet anchor

8. The RF shield vendor must perform a pull test on each anchor (equal to the clamping force) before installation. Results must be provided to the GE Healthcare Project Manager of Installation (PMI)

5.4.3 Dock Anchor Mounting Requirements

Illustration 3-4: Dock Anchor Mounting Options



1. The RF Shield vendor must design and install the dock anchor bolt
2. The dock anchor hole must be drilled after the Magnet is installed
3. The dock anchor must not contact floor rebar or other structural steel
4. The dock anchor must electrically contact the RF shield at point of entry
5. The dock anchors must have the following properties:

   a. Anchors must be two-part assembly (male/female)

   b. Female side must be expansion- or epoxy-type

   c. Male side must be a bolt or threaded rod with appropriate-sized nut (bolt or rod must be removable--not epoxied or cemented in place)

   d. Anchors must be electrically conductive
   e. Anchors must be non-magnetic
   f. Anchors must not induce galvanic corrosion with the RF shield
   g. Anchors must be commercially procured
   h. The anchor rod hole clearance in the dock anchor base is 0.43 in. (11). The anchor rod diameter must be sized appropriately
   i. Anchors must meet the following clamping force: 700 lbs (3,150 N)
   j. The anchor rod must not extend less than 1.75 in. (50 mm) above the finished floor
   k. The anchor rod must not extend more than 2.75 in. (70 mm) above the finished floor
6. The RF shield vendor must perform a pull test on each anchor (equal to the clamping force) the following tests. Results must be provided to the GE Healthcare Project Manager of Installation (PMI)

5.4.4 RF Shielding Integrity Reliability Requirements

1. Ensure all joints and mechanical connections remain secure:
   a. All solder joints clean and properly prepared
   b. All mechanical fasteners sufficiently tightened and secured
   c. Do not use rivets or self-tapping screws (as these tend to loosen over time due to vibration)
2. Prevent RF shield corrosion:
   a. Avoid contact between dissimilar metals
   b. Ensure all joints and seams are properly dressed using proper materials

   NOTE: Sacrificial anodes are recommended
3. Doors and door frames must be structurally stiff to prevent physical changes to the RF shield

6 Finished Room Requirements

CAUTION

Personnel Injury or Equipment Damage
Metallic objects may become projectiles if not properly secured.
Remove or properly secure any metallic objects within the finished room.

1. Non-ferrous/non-metallic materials or components should be used in the Magnet room
2. Ferrous components or material in the Magnet room that could be removed for servicing, cleaning, or replacement must be secured to prevent the ferrous material from becoming a projectile (ferrous components or material must also be identified as ferrous to prevent untrained personnel from working on the ferrous material while the magnet is energized)

6.1 Walls

1. GE Healthcare recommends wall coverings to protect the RF shielding (wall coverings may be removable, if required, to access the RF shield)
2. Metallic electrical conduit inside walls and ceilings may be used. Conduit for receptacles must be metallic
3. An enclosure (i.e., PEN closet) must be provided to restrict access to the PEN wall and for storage of excess interconnections
   a. The PEN closet must have a mechanical locking mechanism to restrict access to the PEN panels
   b. The PEN closet must enclose the minimum service area in the Magnet room as shown in Chapter 4, PEN and SPW Wall Opening Requirements.
   c. The PEN closet may be expanded to provide an area for excess cable storage with the following requirements:
      i. Excess cable must not be stored within the minimum service area
      ii. Excess cable must not interfere with access or servicing of the PEN panel or SPW
      iii. The area within the PEN closet to store the cable should be sized to accept a 22 in (559 mm) cable loop (2x the minimum bend radius of the largest cable)
   d. PEN closet must allow free air exchange of 400cfm (680 m^3/hour) between the Magnet room and PEN closet for MR system blowers. Airflow may be achieved through door louvers or other openings in the PEN closet that meet all other PEN closet requirements

   NOTE: The primary source of airflow must be from the Magnet room. Openings into the area above a false ceiling or other storage areas should be minimized.

6.2 Doors and Magnet Access Openings

1. The finished opening of the main door must be at least 43 in. (1092 mm) to allow for helium dewars and patient tables

2. The finished opening of the main door must be positioned to allow the Gradient Cart to move into the room
3. Threshold height must not exceed 1 in. (25 mm) on both sides of the door with a maximum 10 degree threshold inclination
4. Patient viewing windows recommended dimensions are 48 in. wide by 42 in. high (1219 mm x 1067 mm) and 72 in. (1829 mm) above the finished floor

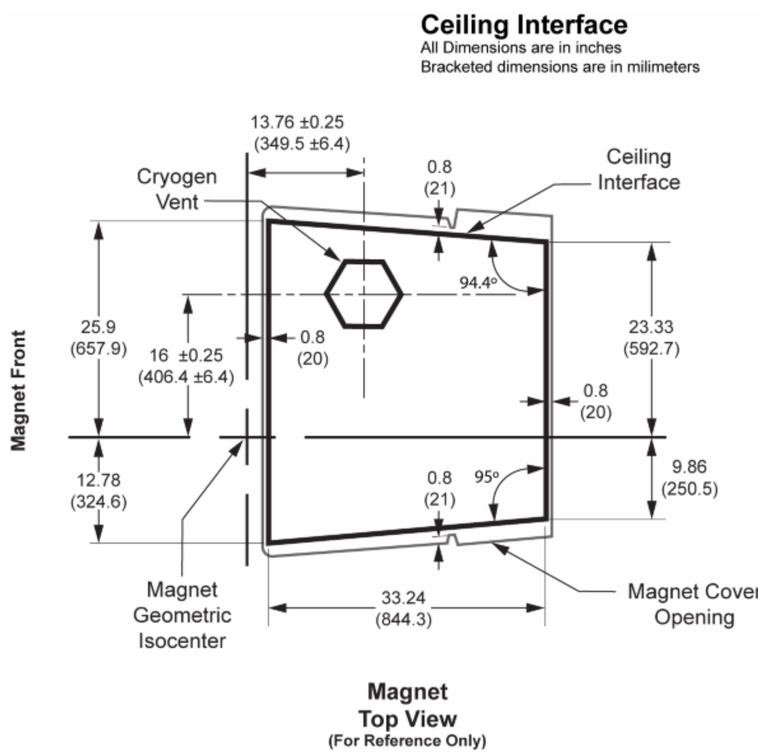
   NOTE: IEC requires the patient, while in the bore, be in full view of the operator. GE Healthcare recommends using a window, although other means (e.g., camera and video display) may be used as long as all IEC requirements are met

5. The magnet delivery requires opening into the room to allow access for the magnet and any rigging

6.3 Finished Ceiling

1. The customer is responsible for the finished ceiling, including any cable enclosures
2. The illustration below shows the maximum dimensions of a customer supplied enclosure at the magnet opening (the ceiling opening size can vary based on customer requirements)

Illustration 3-5: Ceiling Interface



6.4 Magnet Room Floors

1. The finished floor must support the weight of all components (e.g., patient table, gradient coil replacement cart) throughout operation and service life

2. The finished floor must be water resistant to protect the subfloor and shielding from water damage
3. The customer is responsible for providing flooring to meet the maximum 8 kV ESD requirement for GE Healthcare equipment
4. Magnet, Enclosure, and Patient Table areas (shown below) must be flat and level to 0.3125 in. (8 mm) between high and low spots over any 120 in. (3048 mm) distance
5. If the Magnet is mounted directly to the floor, see RF Shielded Room Requirements for mounting bolt requirements
6. When using the GE Healthcare supplied VibroAccoustic Dampening option, use 24 in. x 65 in. (610 mm x 1651 mm) for each pad to calculate floor loading
7. RF shield seams, joints, or overlaps must not be located under the VibroAcoustic mats

Illustration 3-6: Magnet Room Floor Levelness Area

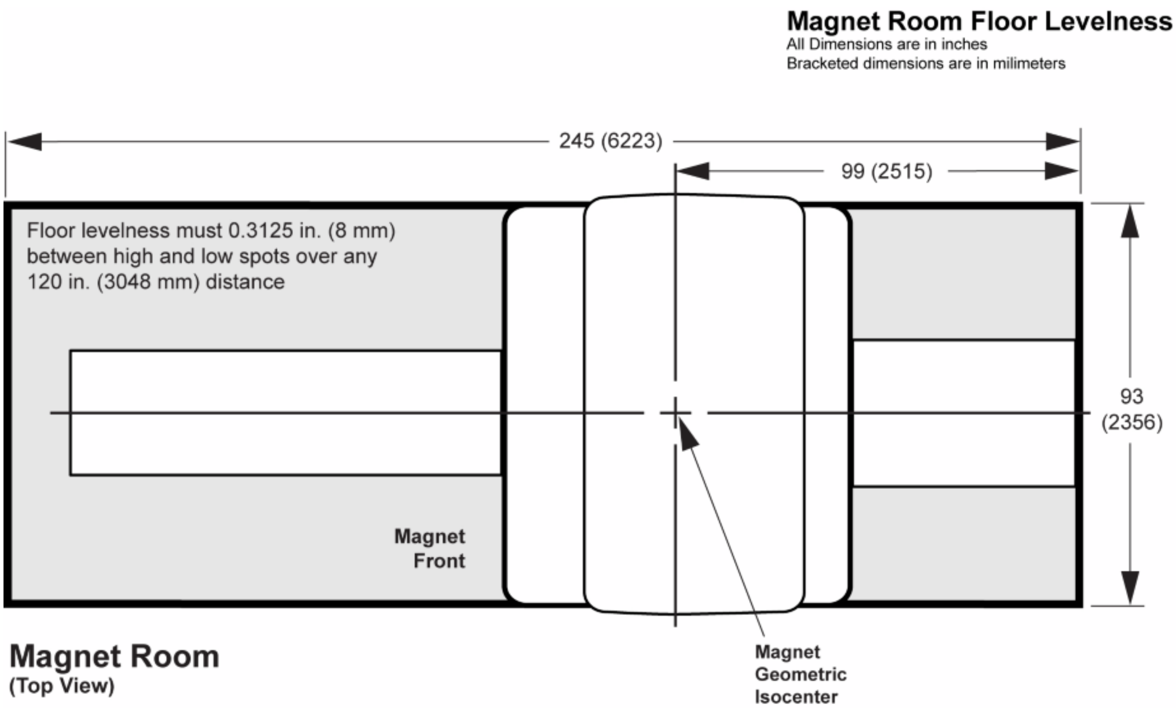
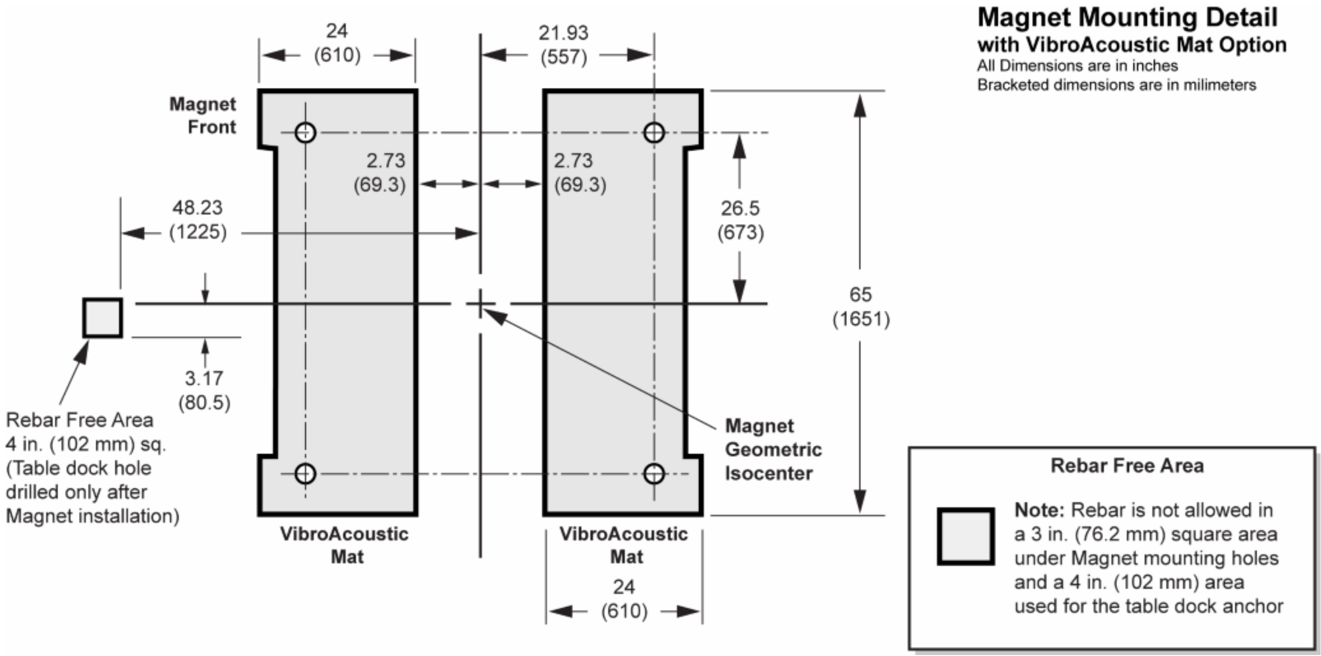


Illustration 3-7: Magnet Mounting Detail



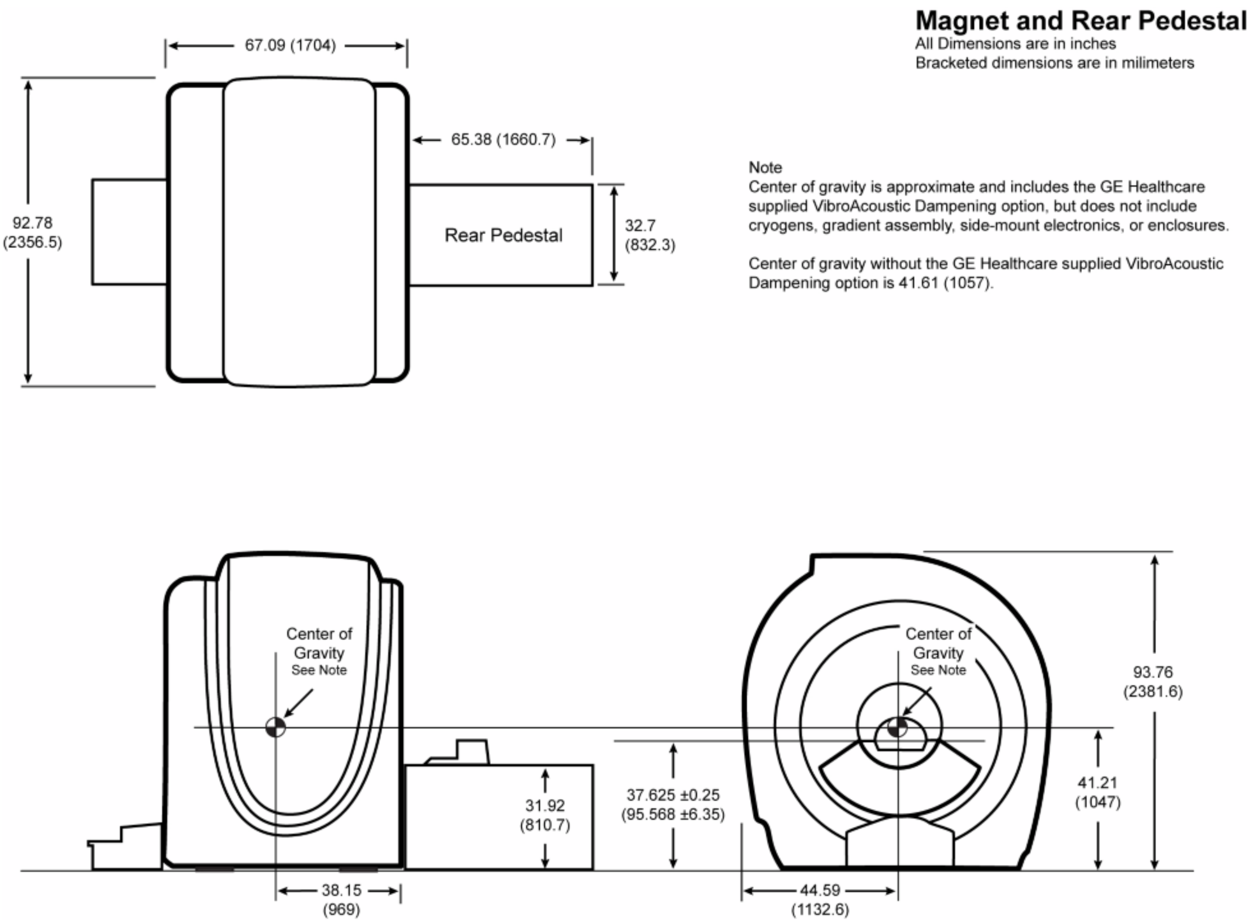
7 Magnet Room Equipment Specifications

7.1 Magnet (MAG) Specifications

Magnet weight (installed): 11,475 lbs (5,205 kg)

Rear Pedestal weight: 212 lbs (96 kg)

Illustration 3-8: Magnet (MAG) and Rear Pedestal



7.2 Patient Table (PT) Specifications

Weight, empty: 418 lbs (190 kg)

Weight with maximum patient weight of 500 lbs (227 kg): 850 lbs (386 kg)

Illustration 3-9: Patient Table (PT)

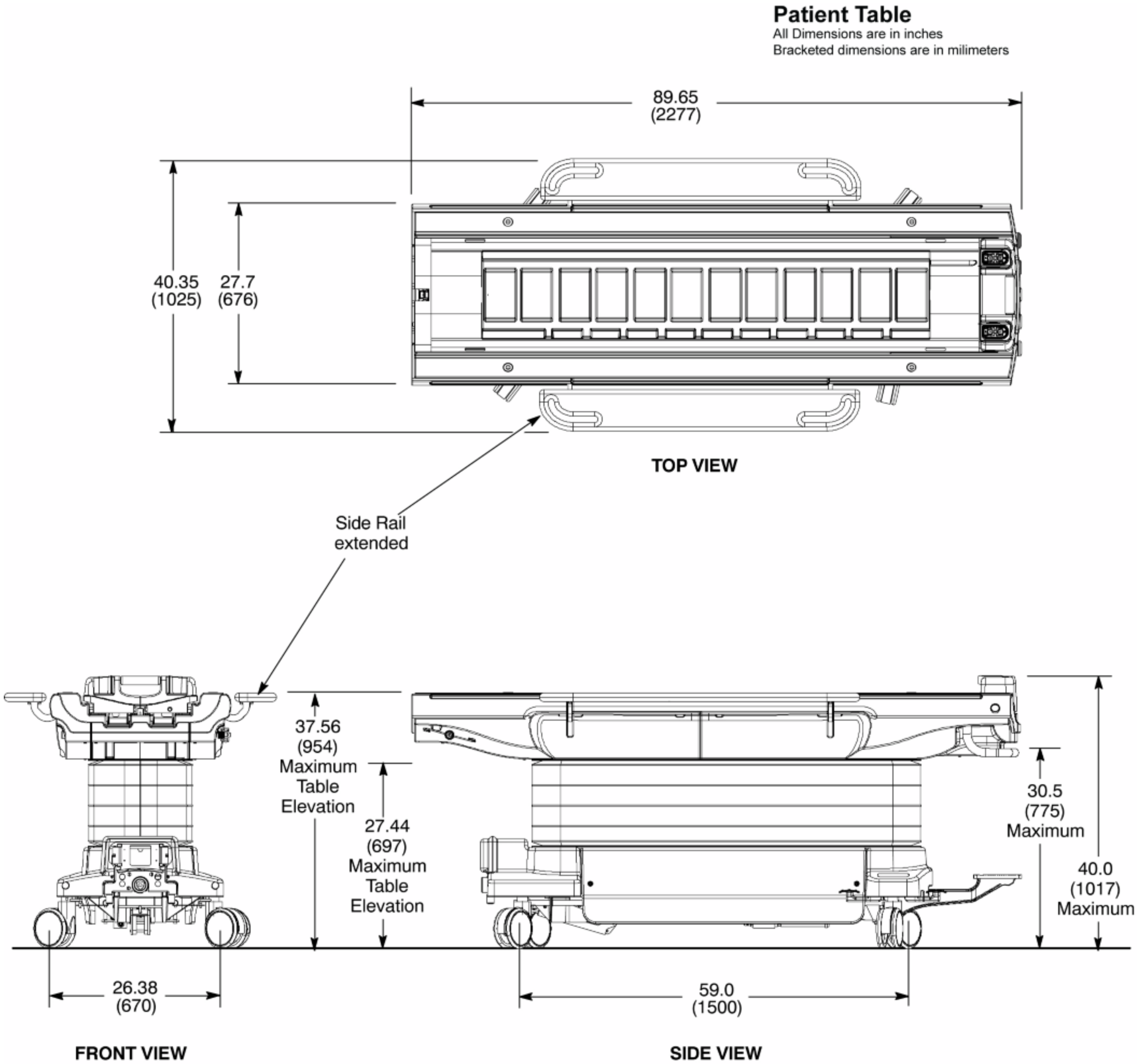
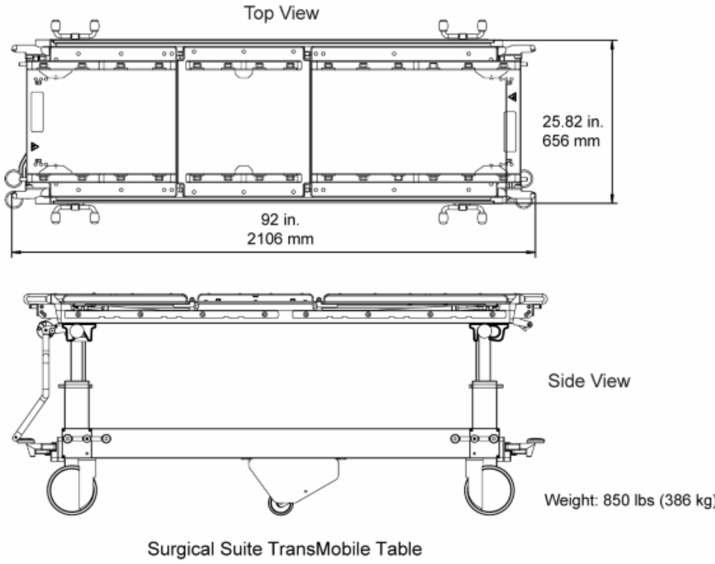


Illustration 3-10: Optional Surgical Suite Transmobile Table



7.3 Magnet Rundown Unit (MRU) Specifications and Requirements

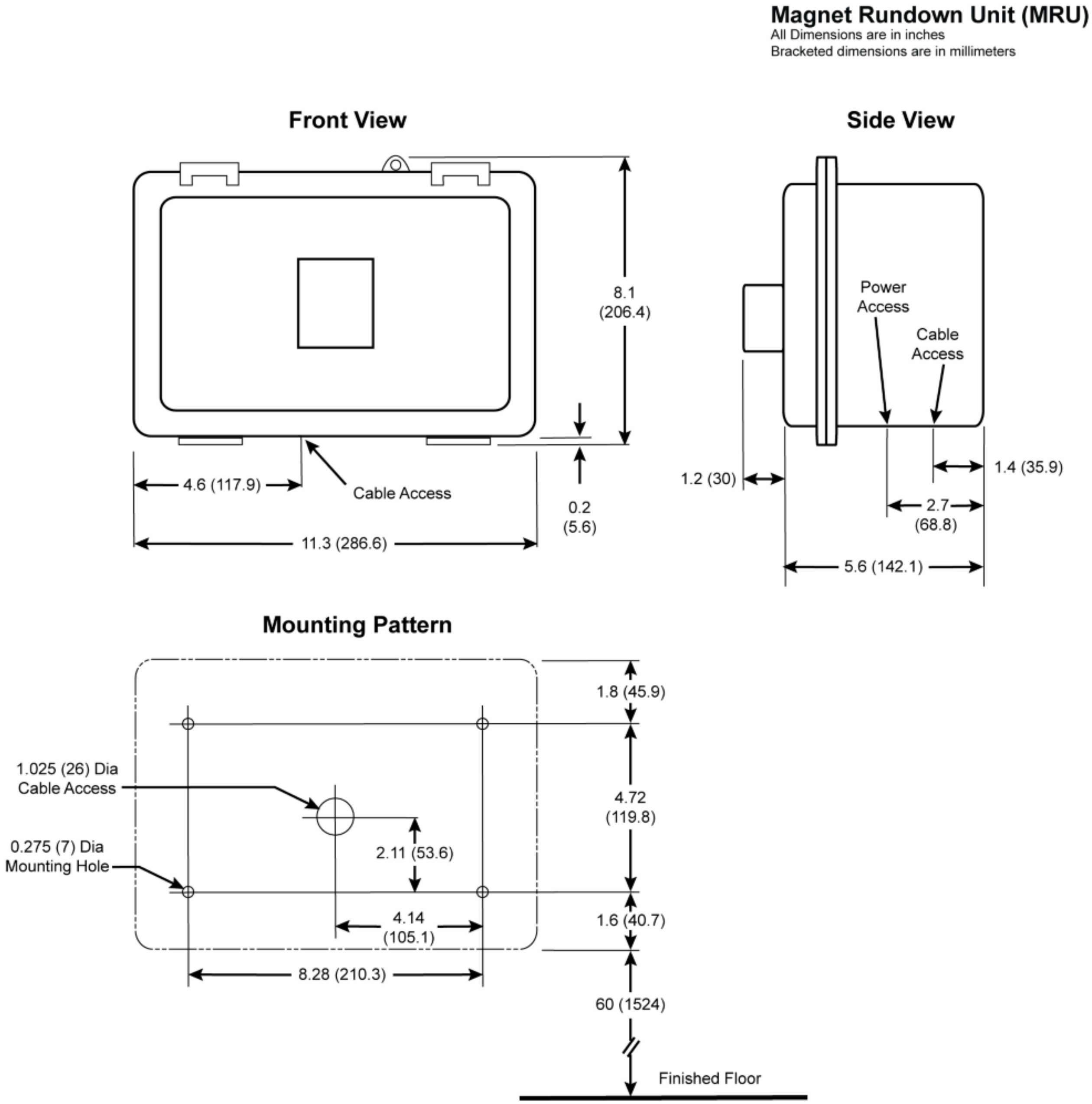
1. Location: The bottom edge of the MRU must be mounted 60 in. (1524 mm) above the Magnet room floor near the front of the magnet enclosure
2. Weight: 7 lbs (3.2 kg)
3. Magnetic field limit: 200 gauss (20 mT)
4. The MRU is installed by the facility contractor
5. The MRU requires the following facility supplied power:

NOTE: Note: An optional remote MRU may be installed outside the magnet room. The remote MRU does not require facility power. For more information, refer to MRU vendor manual.

Table 3-4: MRU Facility Power Requirements

Parameter	Requirements	
Voltage / Frequency	100-120 VAC	50/60 Hz
	200-220 VAC	50/60 Hz
Phase	1	
Maximum Amps	1.0	
Connection type	Hard wired in unit. 1/2 in. PVC Schedule 40 Conduit recommended	
Availability	Continuous	
Circuit Breaker	Dedicated AC disconnect required for both live and neutral connections	

Illustration 3-11: Magnet Rundown Unit (MRU)



7.4 Oxygen Monitor Sensor Specifications

See Chapter 5, Oxygen Monitor (OXY)

8 Magnet Room Venting Requirements

8.1 Overall Requirements

All vent components must be accessible for inspection, cleaning, or maintenance

8.2 HVAC Vent Requirements

1. All components of the HVAC system are supplied by the customer
2. RF Shield vendor must install open pipe or honeycomb HVAC waveguides
3. Waveguides must be nonmagnetic and electrically isolated
4. Incoming air must contain at least 5% air from outside the Magnet room (inside or outside the facility)

8.3 Emergency Exhaust Vent Requirements

1. All components of the exhaust vent system are supplied by the customer
2. The exhaust vent system must be operational before the magnet is installed
3. The exhaust intake vent must be located near the magnet cryogenic vent at the highest point on the ceiling
4. The Magnet room exhaust fan and exhaust intake vent must have a capacity of at least 1200 CFM (34 m^3/minute) with a minimum 12 room air exchanges per hour
5. The exhaust fan must be placed above RF shielding located outside 10 gauss (1mT) and with appropriate waveguide
6. The system must have a manual exhaust fan switch near the Operator Workspace (OW) and in the Magnet room near the door (the switches must be connected in parallel)

   NOTE: If the Magnet room contains an optional oxygen monitor, the Magnet room switch is not required.
7. All system components must be accessible for customer inspection, cleaning, and maintenance

Illustration 3-12: Magnet Room Exhaust Fan Schematic

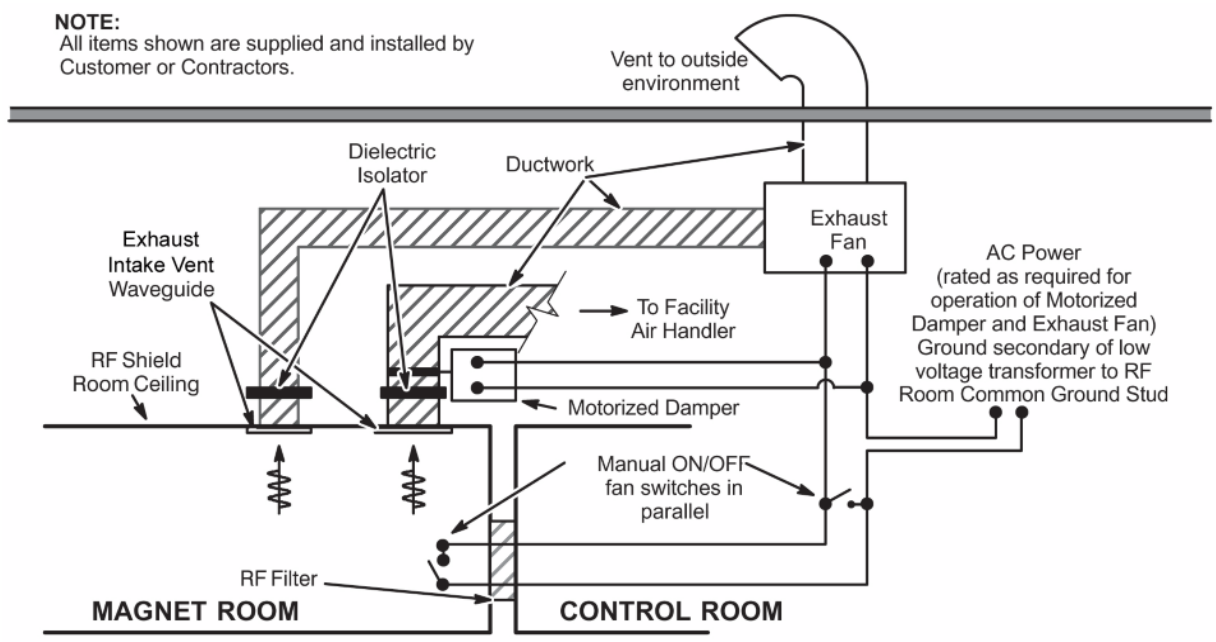
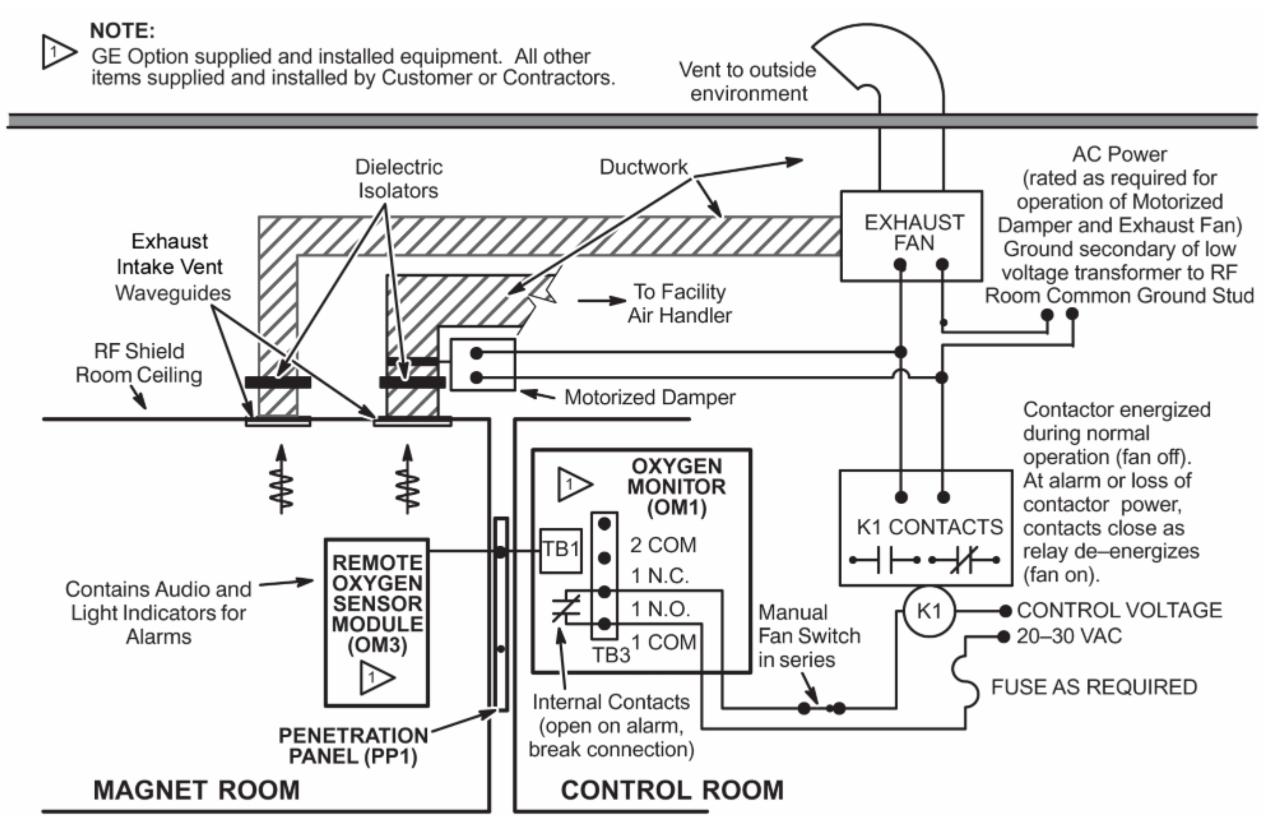


Illustration 3-13: Magnet Room Exhaust Fan Schematic with Optional Oxygen Monitor



8.4 Pressure Equalization Vent Requirement

An additional pressure equalizing waveguide vent in the magnet room ceiling or in the wall (with waveguide top edge located at ceiling) to prevent air pressure from restricting movement of the Magnet room door. The vent minimum size must be 576 sq in. (372,100 sq mm).

8.5 Cryogenic Venting

The MR System requires an outside vent to allow helium gas to escape during magnet quench. The vent must be properly installed to ensure the gas does not escape into the building. The vent must be connected to the magnet within 24 hours of installation in the magnet room.

Note the following:

1. All pipe or tube dimensions specified in this document are outside diameters unless otherwise noted
2. See Chapter 7, Magnet Cryogenic Venting Pressure Drop Reference Tables to calculate pressure drop for a specific system

Table 3-5: Magnet Cryogen Specifications

Magnet Types	Helium Volume gallons (liters)	Peak Helium Flow During Quench ft³ per min (m³ per min)	Magnet Vent Pipe OD inches (mm)
DVw 1.5T Magnet	468 (1770)	2737 (77.5) [Gas]	8 (203.2)

8.6 Vent Requirements Inside the Magnet Room

8.6.1 General

1. Do not remove or modify the vent adaptor bolted to the magnet
2. The GE Healthcare supplied vent tube must be bolted directly to the magnet vent adaptor bolt flange
3. The vent tube may be cut to a minimum of 4 inches (10.6 cm) from the top of the flange
4. The vent must be located within 0.25 in (6.35 mm) of the location (in relation to isocenter) shown in Illustration 3-15

8.6.2 Vent Size

The total pressure drop of the cryogenic vent system (from the magnet vent interface to the termination point outside the building) must be less than 17 psi (117.2 kPa). The pressure drop of the RF shield waveguide must be included in the overall calculation.

8.6.3 Vent Materials

1. The vent material must be one of the following materials with the wall thickness indicated:
   a. SS 304: Minimum 0.035 in. (0.89 mm); Maximum 0.125 in. (3.18 mm)
   b. AL 6061-T6: Minimum 0.083 in. (2.11 mm); Maximum 0.125 in. (3.18 mm)
   c. CU DWV, M or L: Minimum 0.083 in. (2.11 mm); Maximum 0.140 in. (3.56 mm)

2. Either tubes or pipes may be used and must be seamless or have welded seams
3. Corrugated pipe or spiral duct must not be used
4. A bellows pipe less than 1 ft (30 cm) in length may be used as a thermal expansion joint
5. The vent pipe must withstand a maximum pressure of 35 psi (241.4 kPa)
6. Waveguide vent material must match the outside diameter of the magnet vent

8.6.4 Support

1. The vent support assemblies must support the entire vent system and 1850 lbs (8229 N) helium flow reaction force at vent elbows
2. Any vent support between the magnet interface and the isolation joint at the waveguide must be electrically isolated to ensure the integrity of the RF shield
3. The Ventglas joint must not be used as a vent system support

8.6.5 Construction

1. A single dielectric break in the vent system (i.e., Ventglas) is required in the Magnet room to ensure the integrity of the RF shield for the Magnet Room
    a. Ensure the gap between the pipes is 1.0 ±0.25 inch (25.4 ±6 mm)
    b. The outside diameter of the waveguide must match the outside diameter of the GE vent tube within ± 0.125 in. (3 mm)
    c. The Ventglas joint must be accessible for annual inspection or maintenance
2. The Ventglas joint may also serve as a thermal expansion joint
3. All joints except the single Ventglas joint must be welded or brazed
4. All isolation/thermal expansion joints (except the Ventglas joint) must be rated to 4.5 K (-451°F or -268°C) and 35 psi (241.4 kPa)
5. The vent system must be insulated with 1.5 inch (38 mm) thick flexible unicellular insulation to prevent condensation during magnet ramping. Exposed insulation must be covered with a white PVC jacket
6. The installation of the vent pipe section between the waveguide and the supplied magnet vent pipe must not result in any vertical or side load to the waveguide and the magnet vent pipe (e.g., Lorenz clamps must not be used because the rigid connection will transfer load to the magnet vent pipe)

8.7 Vent Requirements Outside the Magnet Room

The customer is responsible for design, installation, and maintenance of all cryogenic venting materials outside the Magnet room, except as noted in the following requirements.

8.7.1 Vent Support

1. The vent support assemblies must be able to support the entire vent system and 1850 lbs (8229 N) helium flow reaction force at vent elbows

2. The dielectric break must not be used as a vent system support

8.7.2 Vent Construction

1. The vent must be routed as directly as possible to the outside. If used, elbows must be standard or long sweep
2. Expansion/contraction joints must be provided for temperature decrease from ambient to 4.5 K (-451°F or -268 °C)
3. A dielectric break must be installed above the waveguide.
    a. The dielectric break gap must be 1.0 ± 0.25 inch (25 ± 6 mm)
    b. A customer supplied wrap or clamp or the GE Healthcare supplied Ventglas may be used to connect the dielectric break
    c. If used, the GE Healthcare supplied Ventglas and clamps are for 8 in. (203 mm) pipe only
    d. The dielectric break must be accessible for inspection or maintenance
4. All components must be rated to withstand the helium flow reaction force at temperatures from ambient to 4.5 K (-451°F or -268°C)
5. Electromechanical fire dampers must not be used. Fusible link fire dampers may be used (with annual inspection)
6. Exit of vent must be covered to prevent ingress of weather elements (i.e., rain, snow, hail, sand, etc.) and foreign material debris (i.e., leaves, bird nests, etc.)
7. Condensate must be prevented from pooling inside any section of the venting system

8.7.3 Vent Exit

CAUTION

Cryogenic Burns or Asphyxiation
During a quench, extremely cold gas or particles are released from the cryogenic venting system. A Quench may occur at any time.
Ensure access to cryogen vent exhaust area is restricted and the released gas does not reenter the building. Refer to the specifications below.

1. An exhaust area in front of the vent 20 feet (6.1 m) long by 15 feet (4.6 meters) wide:
    a. Customer must be restrict and label area with appropriate warning signs
    b. Must not include air intake vents
    c. Must not include any personnel, building components, or objects (movable or stationary)
2. For a rooftop exit:
    a. Use either a horizontal exhaust vent with a 90° elbow and minimal pressure drop or other low pressure drop, high flow rate roof cap
    b. The bottom of the 90° elbow must be at least 3 feet (0.9 meters) above the roof deck (or higher if at risk of being blocked by drifting snow, sand, etc.)

   c. The outlet must be covered with a 0.5 inch (12.7 mm) square screen mesh
   d. The exhaust vent must be included in the pressure drop calculation

3. For a sidewall exit:
   a. Use an exhaust vent with a 45° elbow (with a deflector rated for the helium reaction force) and no restriction in gas flow
   b. The exhaust exit must be at least 12 feet (3.66 meters) above the ground
   c. The outlet must be covered with a 0.5 inch (12.7 mm) square screen mesh
   d. The outlet must be covered to prevent foreign material from entering or blocking the opening (e.g., louvers, etc.)
   e. The exhaust vent must be included in the pressure drop calculation

Illustration 3-14: Cryogenic Vent Installation Detail

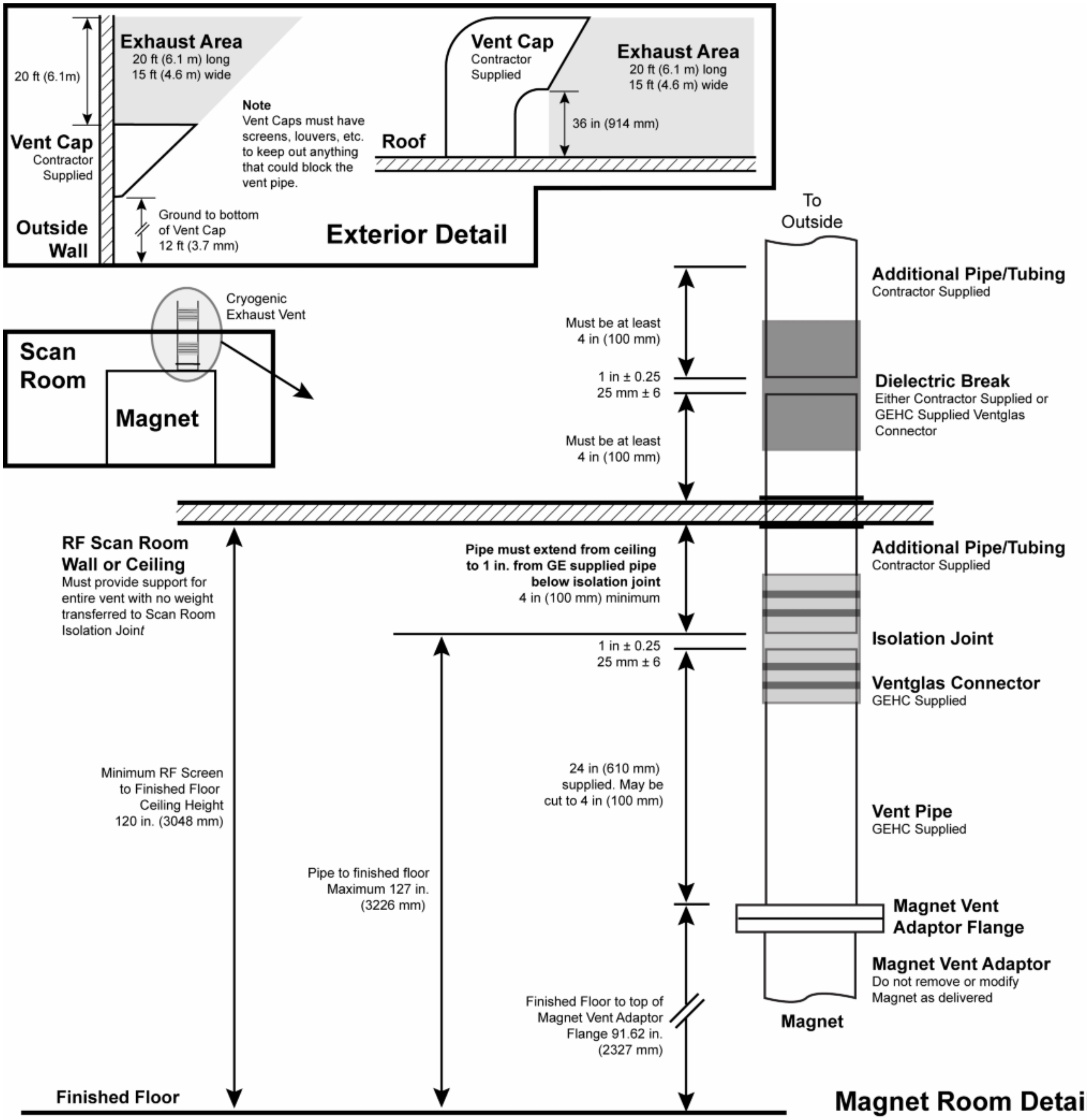
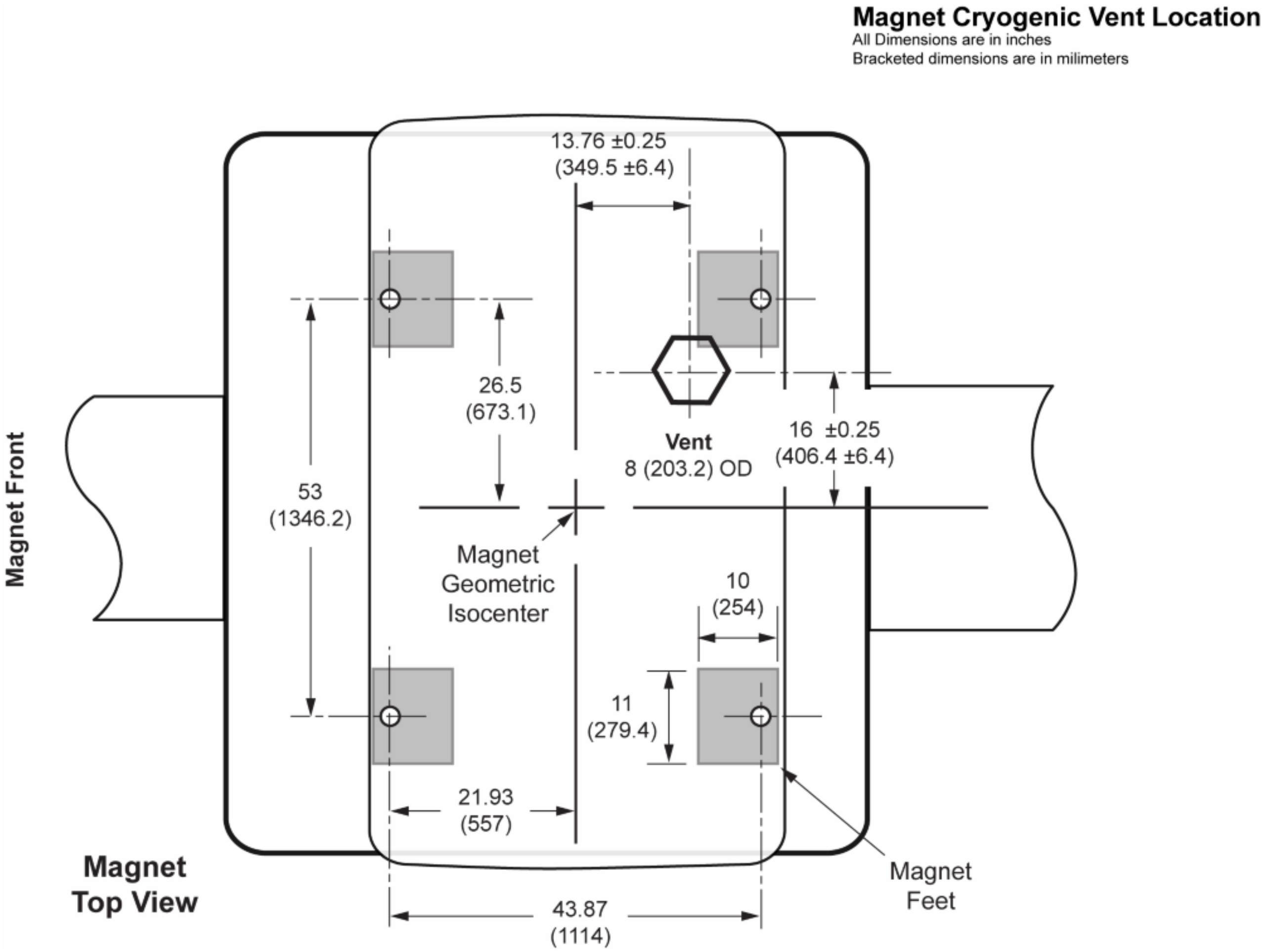


Illustration 3-15: Magnet Cryogenic Vent Location



9 Magnet Room Electrical and Grounding Requirements

9.1 Electrical Line and Filter Requirements

1. RF Shielded Room vendor and electrical contractor must coordinate installation of all electrical lines through the RF shielding
2. The RF Shielded Room vendor must supply electrical line filters for all lines through the RF shielding (excluding electrical lines through the GE supplied Penetration panels) to ensure compliance with the RF Shielded Room attenuation requirements
3. Electrical line filters must be located outside the 200 gauss (20 mT) line

9.2 Lighting Requirements

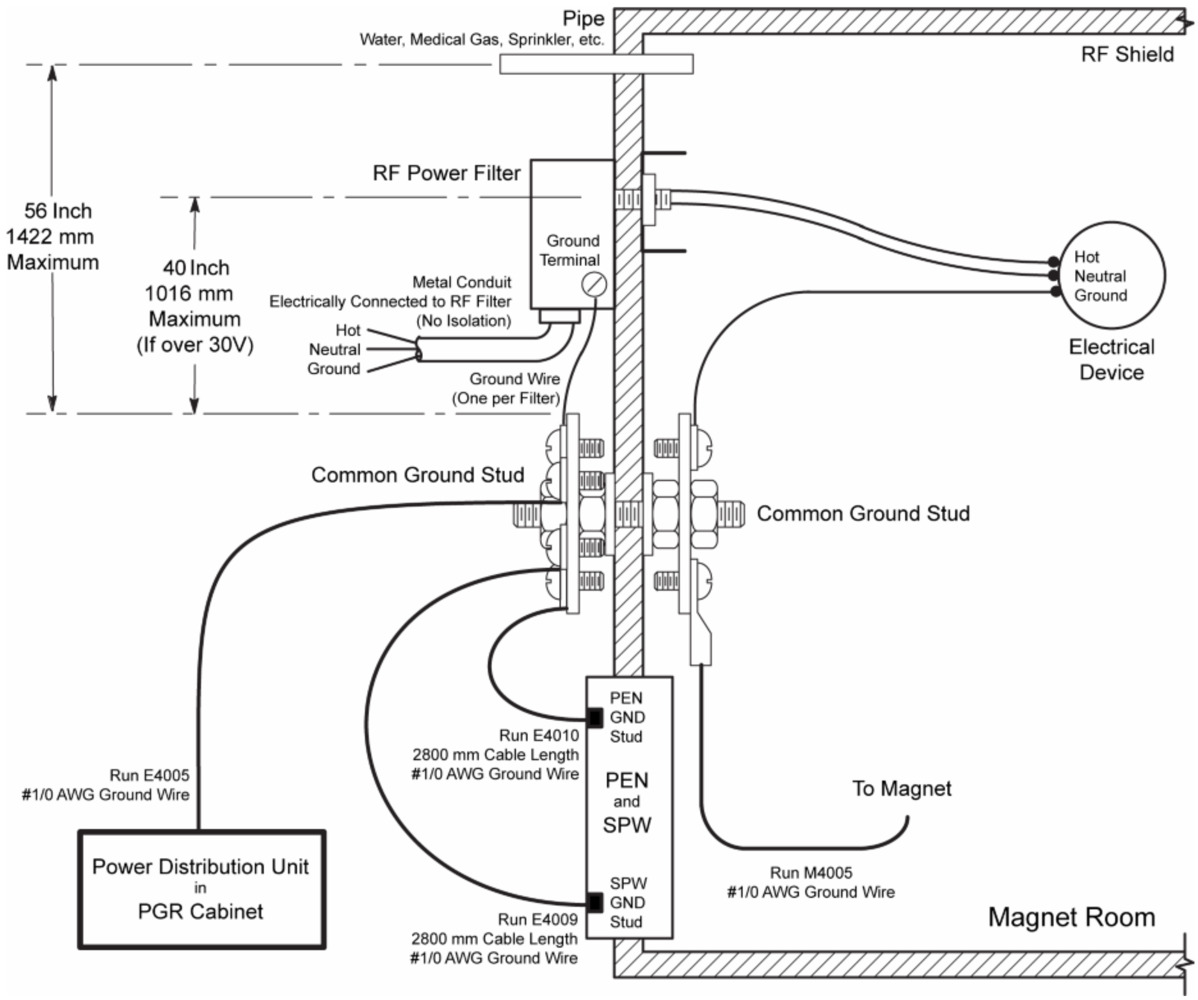
1. All lighting fixtures and associated components must meet all RF Shielded Room and RF Grounding requirements (e.g., track lighting is not recommended due to possible RF noise)
2. All lighting must use direct current (the DC must have less than 5% ripple)
3. 300 lux must be provided at the front of the magnet for patient access and above the magnet for servicing
4. Fluorescent lighting must not be used in the Magnet Room
5. Lighting must be adjusted using a discrete switch or a variable DC lighting controller
6. SCR dimmers or rheostats must not be used
7. DC LED lighting may be used if the power source is located outside the Magnet Room RF Shield
8. Battery chargers (e.g., used for emergency lighting) must be located outside the Magnet Room
9. Short filament length bulbs are recommended
10. Linear lamps are not recommended due to the high burnout rate

9.3 Grounding Requirements

1. The Penetration Panel Pen Wall and Secondary Pen Wall (SPW) are connected to the RF Common Ground Stud with the GE Healthcare supplied ground cable (refer to Illustration 3-16Chapter 4, PEN and SPW Wall Opening Requirements)
2. RF Power Filters over 30 volts must be located within 40 in. (1016 mm) of the RF Common Ground Stud
3. RF Power Filters of 30 volts or less may be located anywhere on the RF Shield
4. All electrical devices (e.g., outlets, light fixtures, etc.) must have a ground wire from device power source and be grounded to the RF Shield at the RF Common Ground Stud
5. Resistance between any two grounded devices must not exceed 0.1 ohm to ensure equal potential ground system within the Magnet Room (e.g., MGD to PDU)
6. Do not ground non-MR equipment to the MR ground system

7. All metallic pipes (including water, medical gas, sprinklers, etc.) entering the RF Shield, excluding the Cryogenic Vent and floor drains, must be located within 56 inches (1422 mm) of the RF Common Ground Stud
8. The illustration below shows a typical ground layout

Illustration 3-16: Typical Magnet Room Grounding



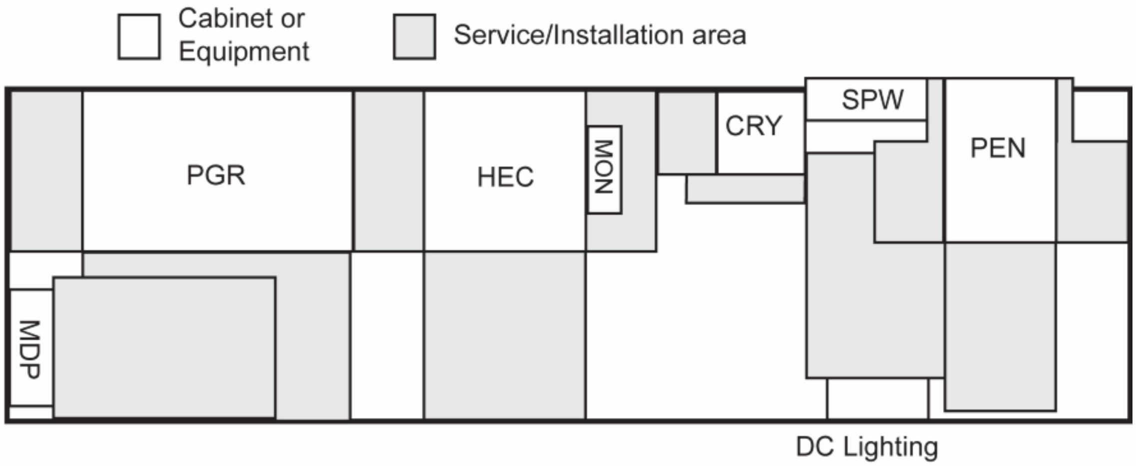
NOTE: See MR System Interconnects Specifications for usable cable lengths.

Chapter 4 Equipment Room

1 Equipment Room Overview

The illustration below shows a typical Equipment room layout.

Illustration 4-1: Typical Equipment Room Layout



Notes:

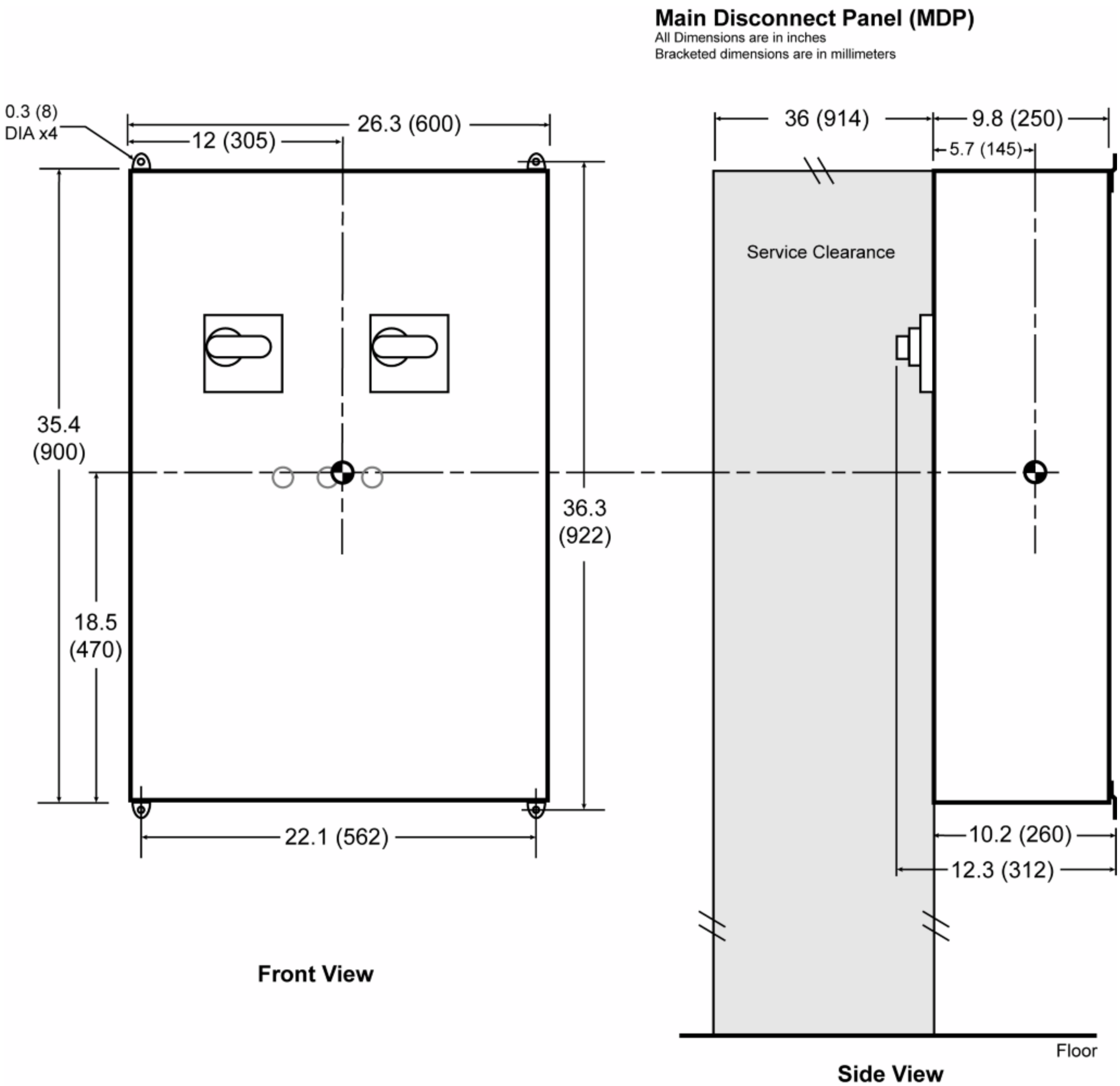
- Layout shown is typical for an approximate 6 ft (1.8) x 20 ft (6 m) Equipment room
- Drawing is to scale, but see individual component descriptions and room requirements for dimensions
- MDP and Lighting converter service access area long dimension shown as 48 in (122 cm)
- Service/Installation areas may overlap as necessary
- Magnet Monitor (MON) may be mounted on either side of the HEC
- Optional equipment is not shown

2 Main Disconnect Panel (MDP) Specifications

The Main Disconnect Panel (MDP) is provided with the MR system.

1. Weight: 130 lbs (59 kg)
2. Magnetic Field Limit: 50 Gauss (5 mT)

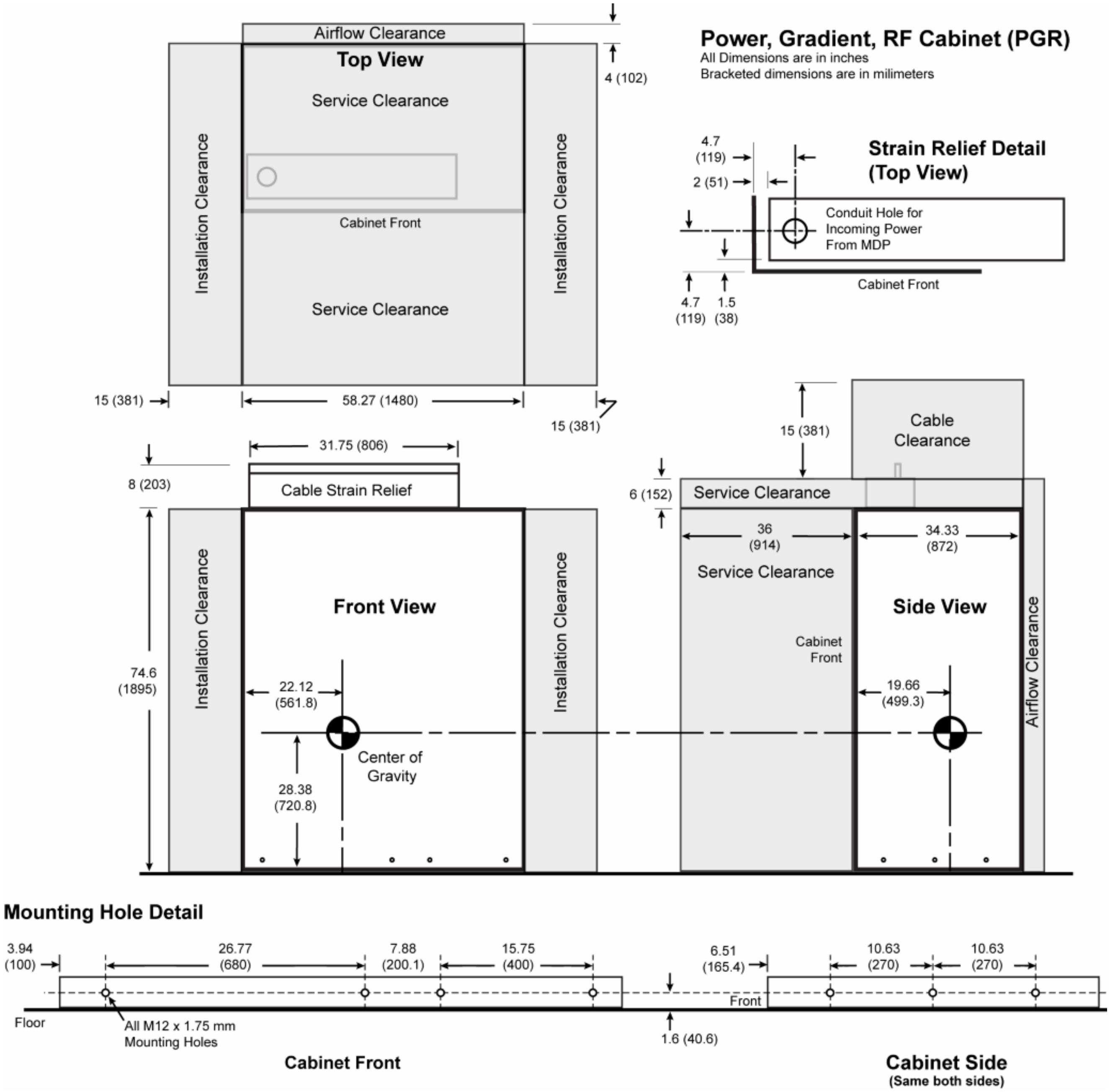
Illustration 4-2: Main Disconnect Panel



3 Power, Gradient, RF Cabinet (PGR) Specifications

1. Weight: 3144 lbs (1426 kg)
2. Magnetic Field Limit: 50 Gauss (5 mT)

Illustration 4-3: Power, Gradient, RF (PGR) Cabinet

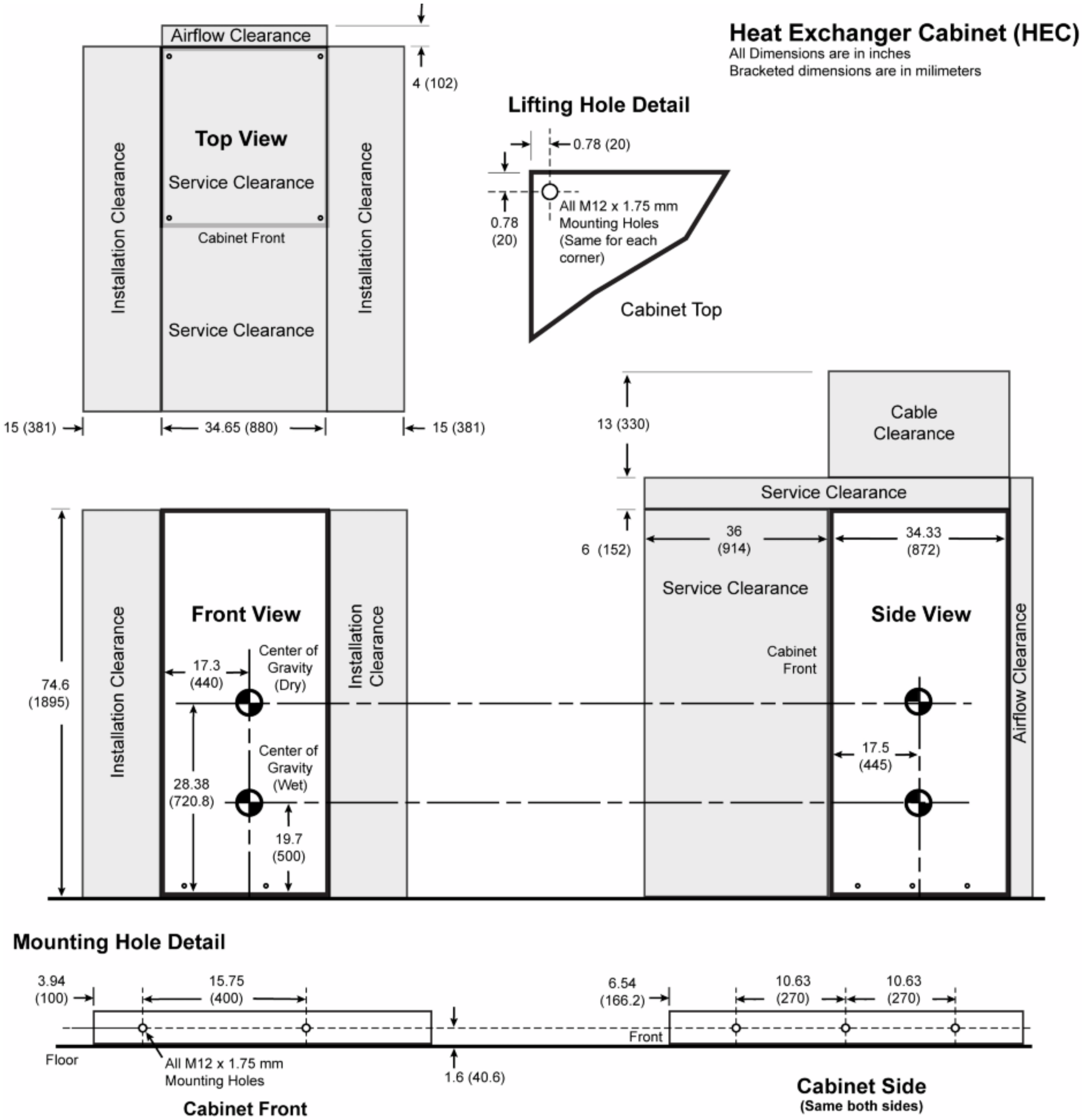


4 Heat Exchanger Cabinet (HEC) Specifications

Facility coolant is supplied to the Heat Exchanger Cabinet (HEC). The HEC provides closed loop chilled water circuits for the Power, Gradient, RF (PGR) Cabinet in the equipment room and the Gradient Coil inside the Magnet Enclosure. The HEC also routes facility chilled coolant to the Cryocooler Compressor (CRY).

1. Weight (approximate):
    a. Dry (shipping – no fluid): 950 lbs (431 kg)
    b. Wet (with cooling fluid): 1350 lbs (612 kg)
2. Magnetic Field Limit: 50 Gauss (5 mT)

Illustration 4-4: Heat Exchanger Cabinet (HEC)



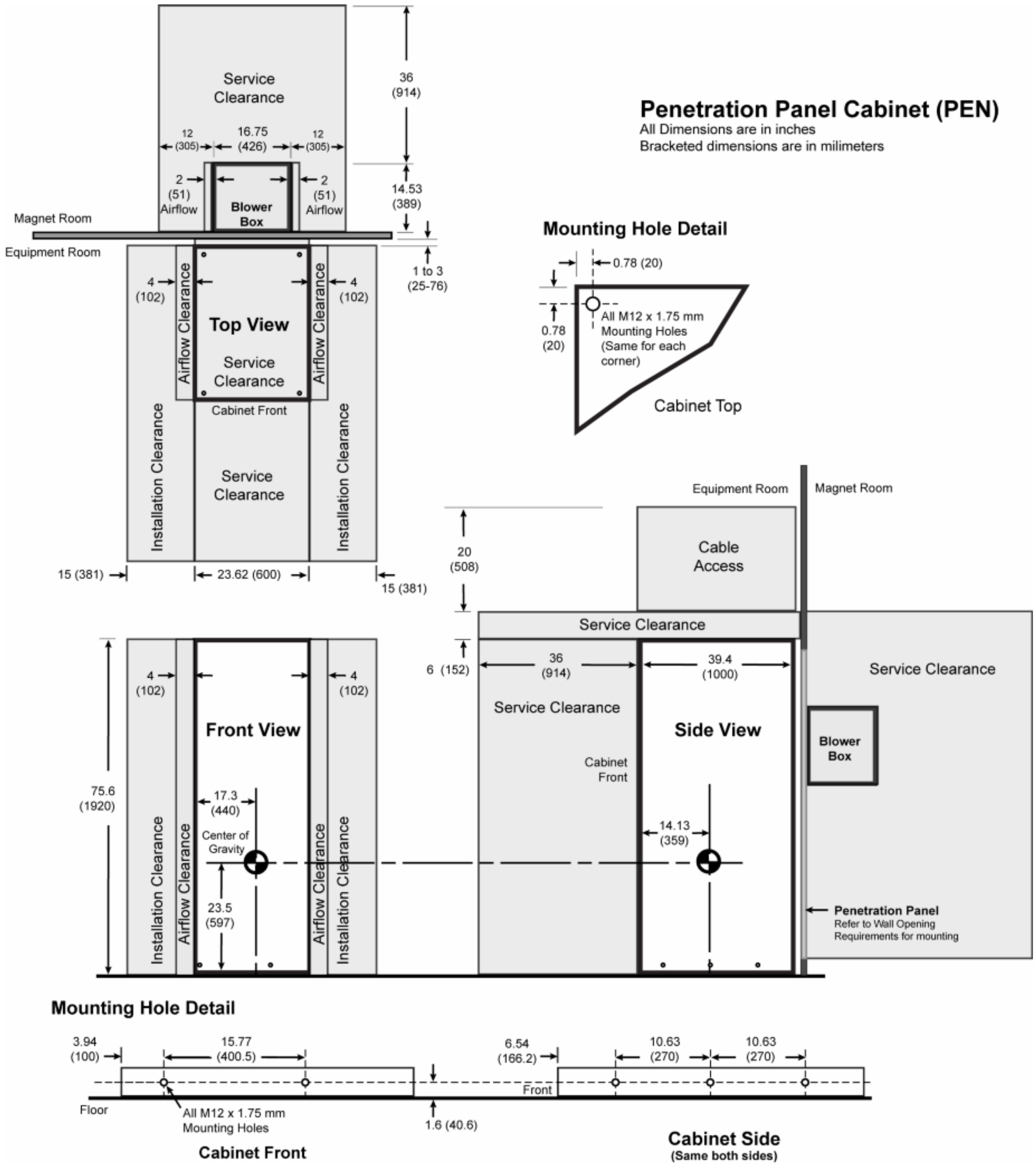
5 Penetration Panel Cabinet (PEN) Specifications

The Penetration Cabinet Penetration Panel provides interconnects from the PEN Cabinet through the Magnet Room RF Shield.

1. Weight: 639 lbs (290 kg)
2. PEN Panel Magnetic Field Limit: 200 Gauss (20 mT) for the entire PEN Panel (i.e., the blower box must be outside the 200 Gauss line)

   PEN Cabinet Magnetic Field Limit: 50 Gauss (5 mT)
3. The PEN cabinet must be positioned directly in front of the PEN Panel. See PEN and SPW Wall Opening Requirements for PEN panel mounting and location requirements

Illustration 4-5: Penetration Panel Cabinet (PEN)



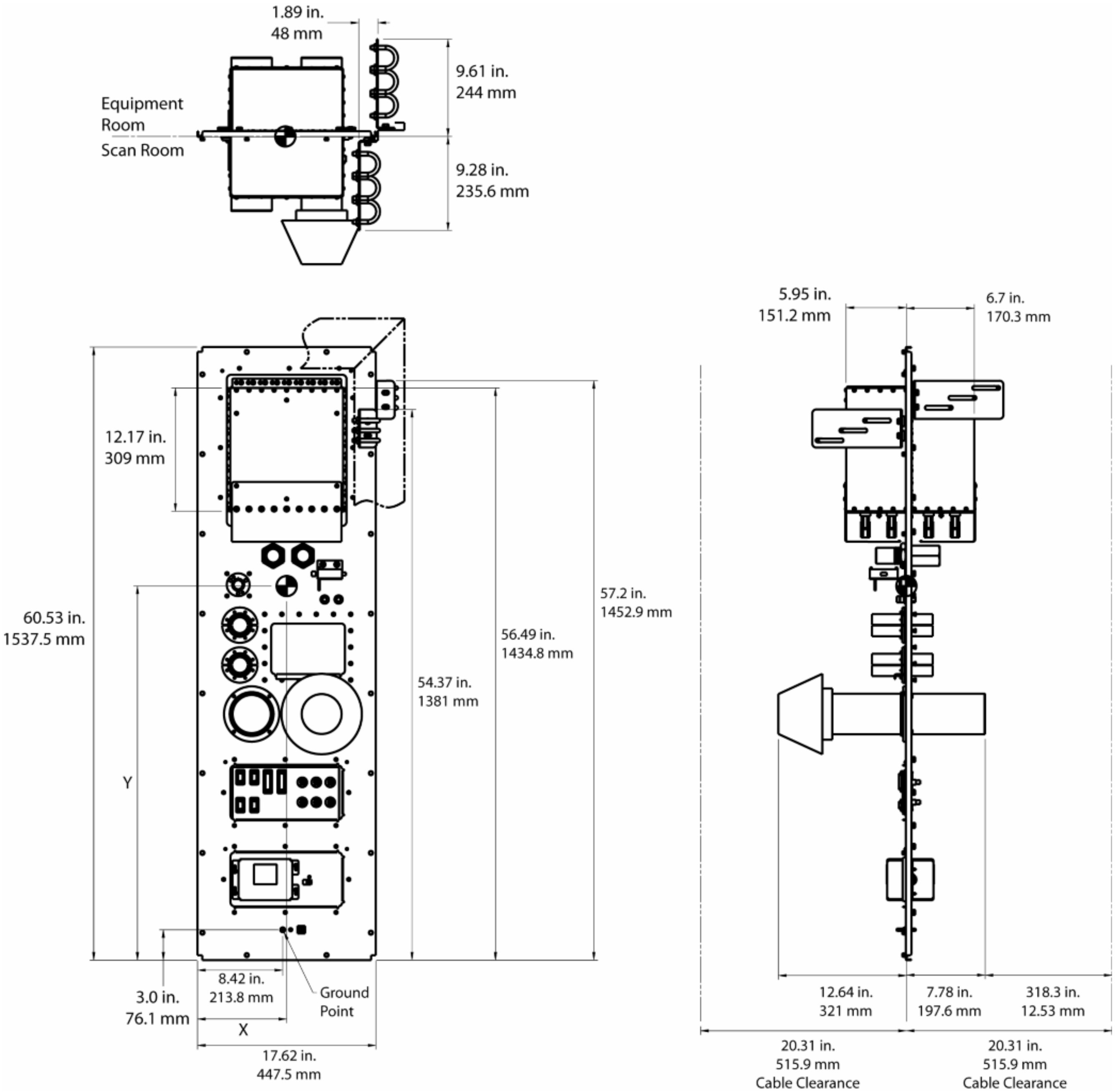
6 Secondary Penetration Wall (SPW) Specifications

The Secondary Penetration Wall (SPW) provides interconnects from the Equipment Room through the Magnet Room RF Shield.

1. Maximum Magnetic Field: 200 Gauss (20mT)
2. See PEN and SPW Wall Opening Requirements mounting and location requirements

.

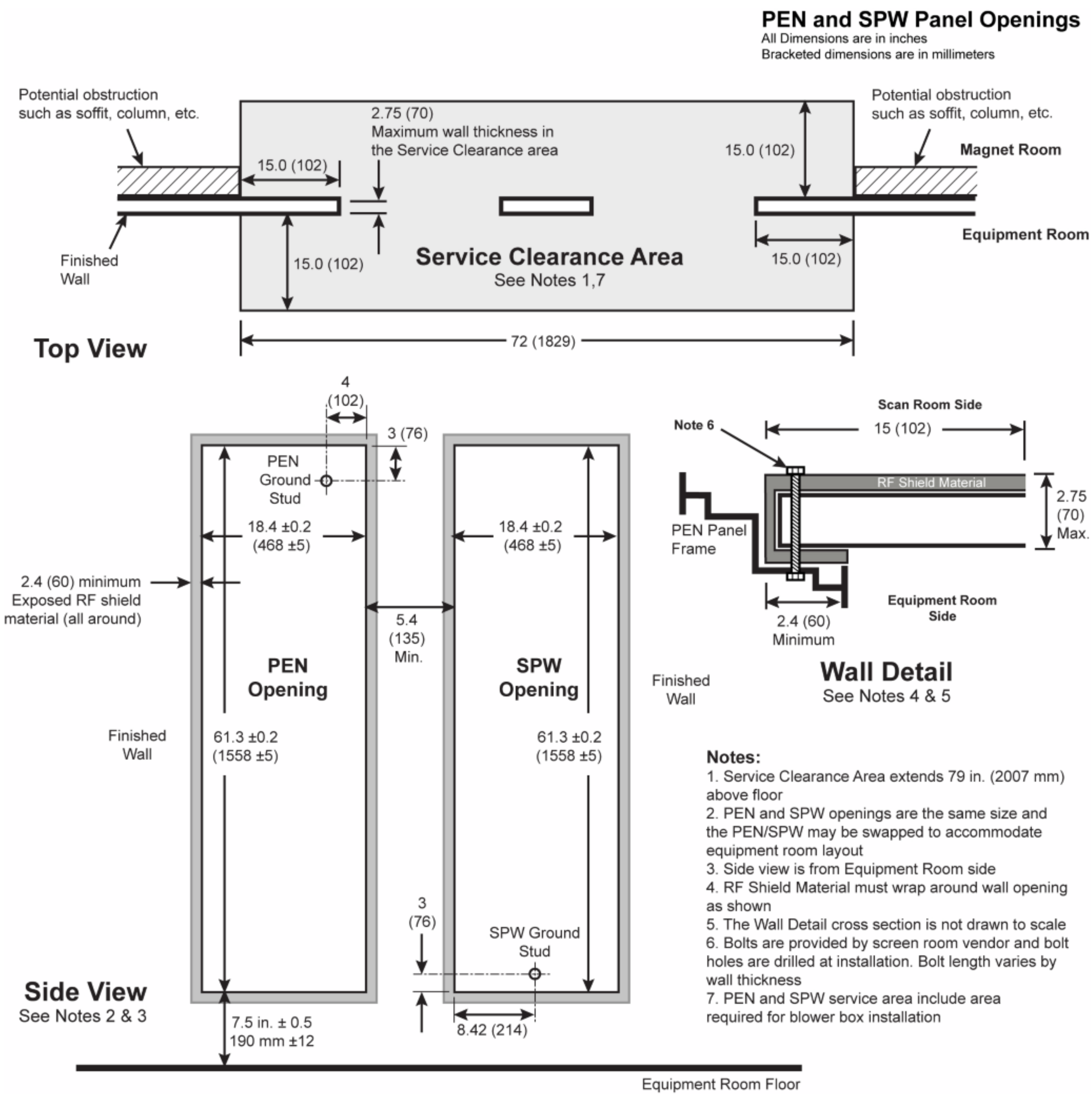
Illustration 4-6: Secondary Penetration Wall (SPW)



7 PEN and SPW Wall Opening Requirements

1. The Equipment Room and the Magnet Room must share at least one common wall to mount the PEN panel and SPW
2. The penetration panel opening requirements are shown in Illustration 4-7

Illustration 4-7: PEN and SPW Panel Openings

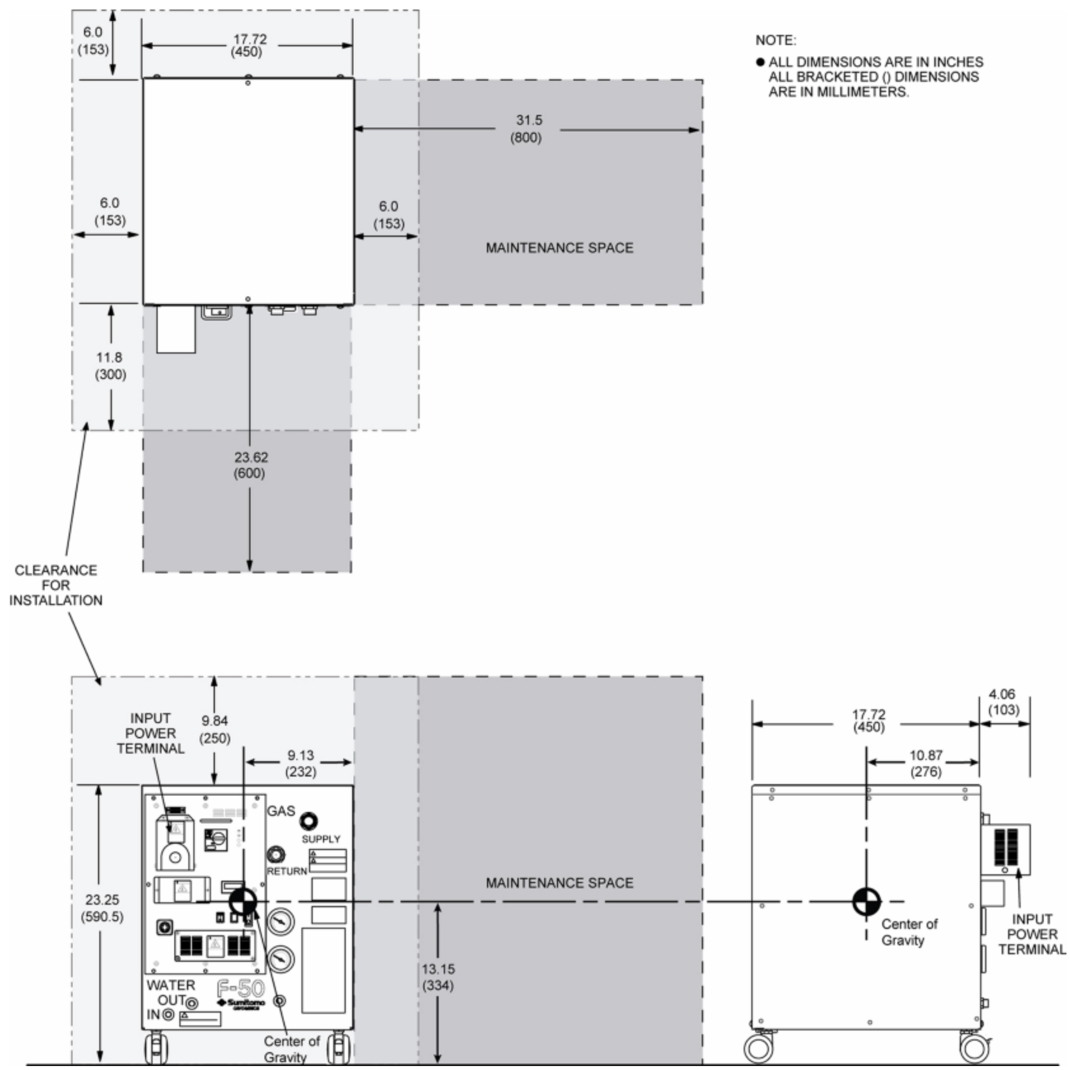


8 Cryocooler Compressor (CRY) Specifications

Water cooling for the Cryocooler Compressor (CRY) is provided from the Heat Exchanger Cabinet (HEC) or facility supplied emergency backup water supply.

1. Weight: 264 lbs (120 kg)
2. Magnetic Field Limit: 100 Gauss (10 mT)

Illustration 4-8: Cryocooler Compressor F-50



9 Magnet Monitor (MON) Requirements and Specifications

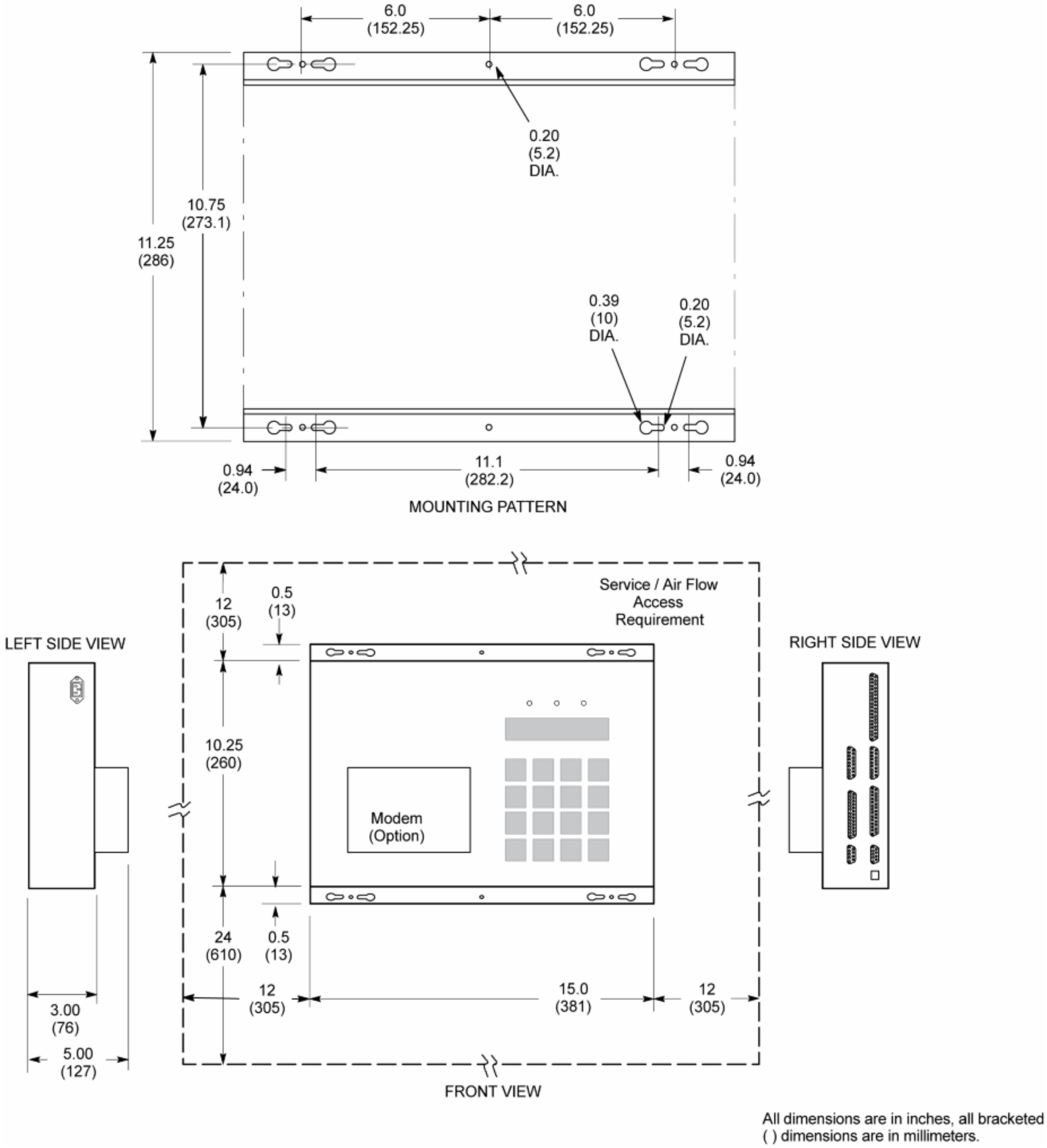
9.1 Requirements

1. Customer must supply T100 network connection with RJ45 connector to the Magnet Monitor (MON)
2. The network connection must not be routed through the Ethernet switch in the Global Operator Cabinet (GOC)
3. The Magnet Monitor requires a 110/220 VAC, 50/60 Hz, 2.0 A facility supplied outlet. Power at the outlet must be continuously available

9.2 Specifications

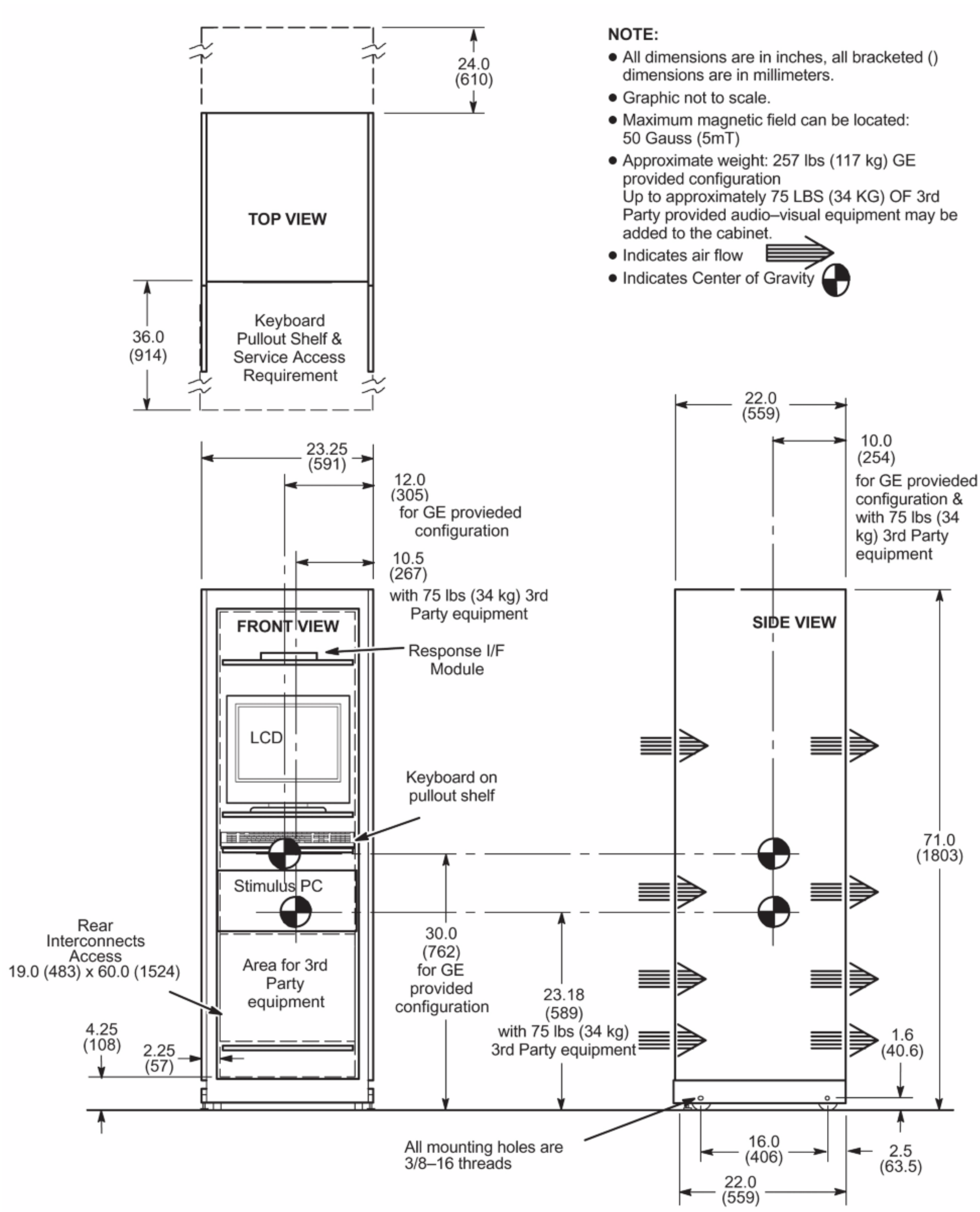
1. Mounting location: On either side of the Heat Exchanger Cabinet (HEC)
2. Weight: 10 lbs (4.5 kg)
3. Maximum gauss limit: 200 gauss (20 mT)
4. Power cord length: 72 in. (1829 mm)

Illustration 4-9: Magnet Monitor (MON)



10 Brainwave Lite (BW) Specifications

Illustration 4-10: Brainwave Lite Cabinet (BW)



11 Magnetic Resonance Elastography (MRE) Specifications

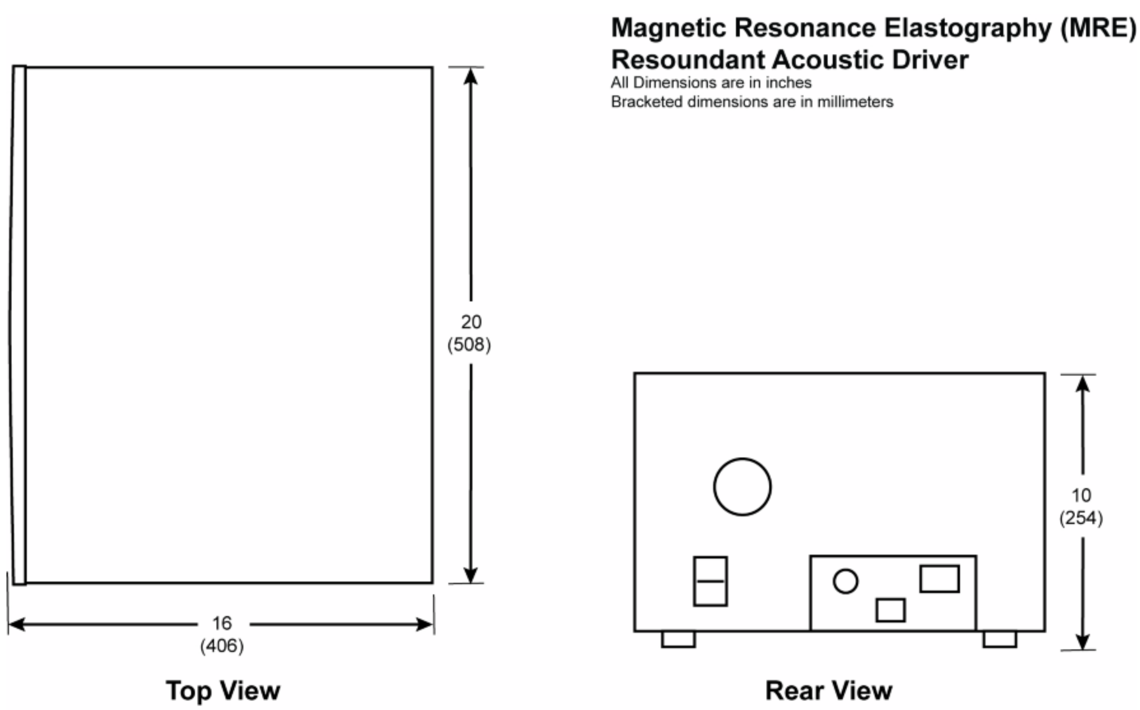
11.1 Requirements

1. Customer must work with the RF shield vendor to provide a waveguide for the 1 in. (25.4 mm)
2. MRE Resoundant Acoustic Driver location is limited to the length of the 1 in. (25.4 mm) tube (see the usable cable lengths in Chapter 6, Section 1.4, Magnetic Resonance Elastography (MRE) Option)
3. The MRE Resoundant Acoustic Driver module requires a 110/220 VAC, 50/60 Hz, 2.0 A facility supplied outlet. Power at the outlet must be continuously available

11.2 Specifications

1. Weight: 53.4 lbs (24.22 kg)
2. Gauss Limit: 50 gauss
3. Power Cord Length:
   - 60 Hz: 240 in. (6096 mm)
   - 50 Hz: 300 in. (7620 mm)

Illustration 4-11: Magnetic Resonance Elastography (MRE) Resoundant Acoustic Driver



This page left intentionally blank.

Chapter 5 Control Room

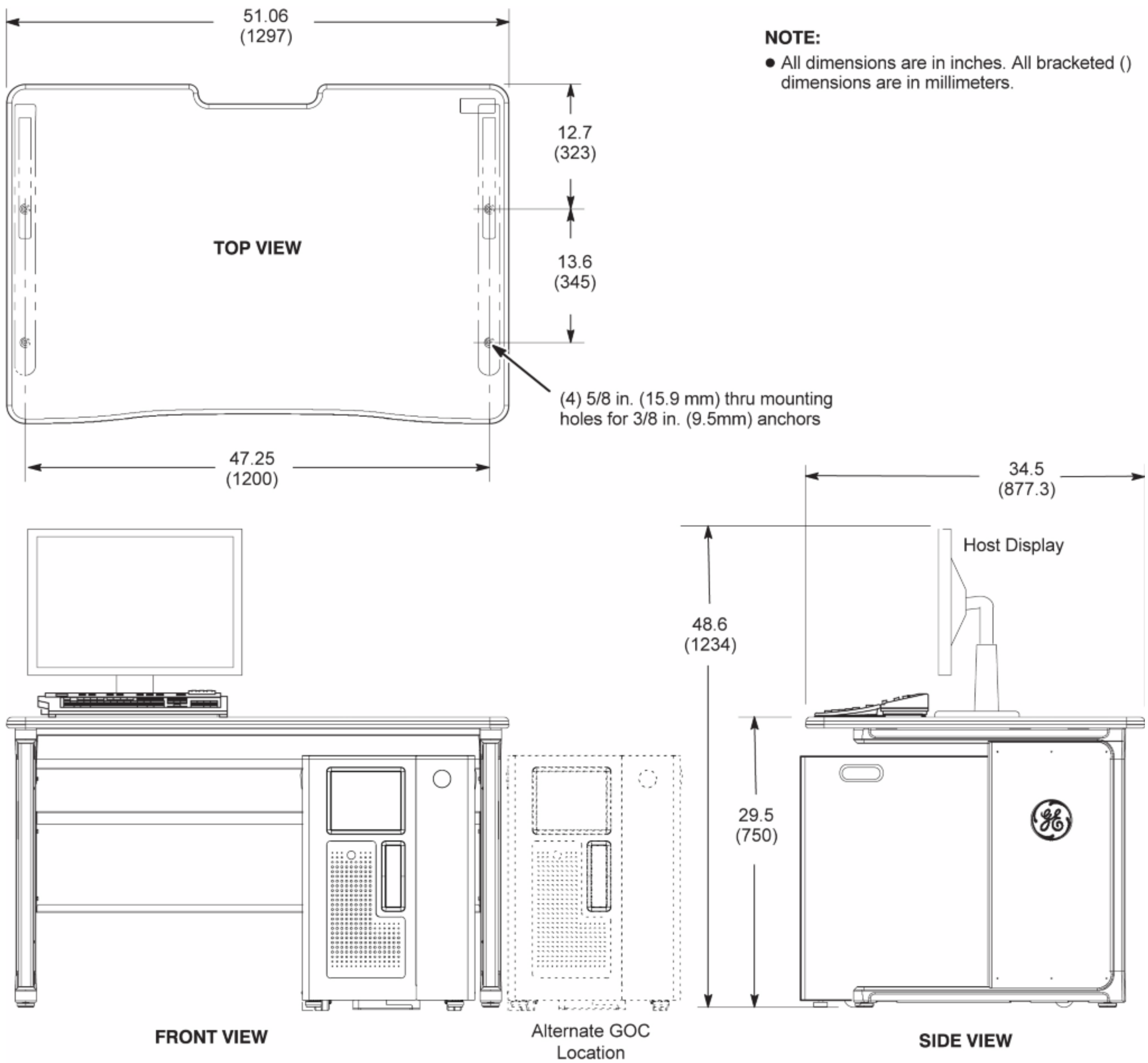
1 Operator Workspace Equipment Specifications

The operator seated at the Operator Workspace must have an unobstructed view of the patient on the Patient Table docked to the Magnet.

1.1 Operator Workspace (OW)

NOTE: The Operator Workspace table is optional.

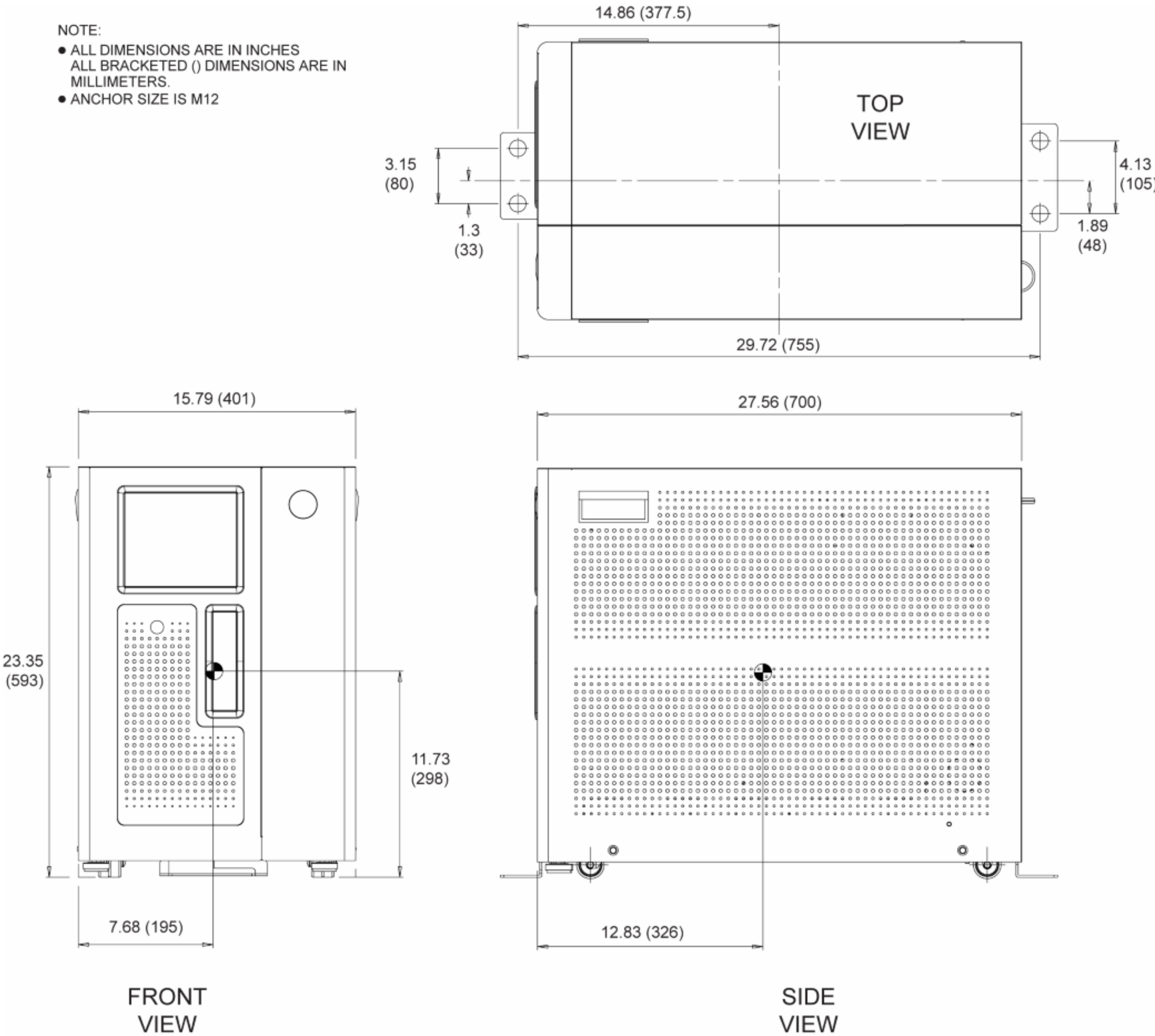
Illustration 5-1: Operator Workspace (OW)



1.2 Global Operator Cabinet (GOC)

1. Weight: 141.75 lbs (64.3 kg)
2. Magnetic Field Limit: 50 Gauss (5 mT)

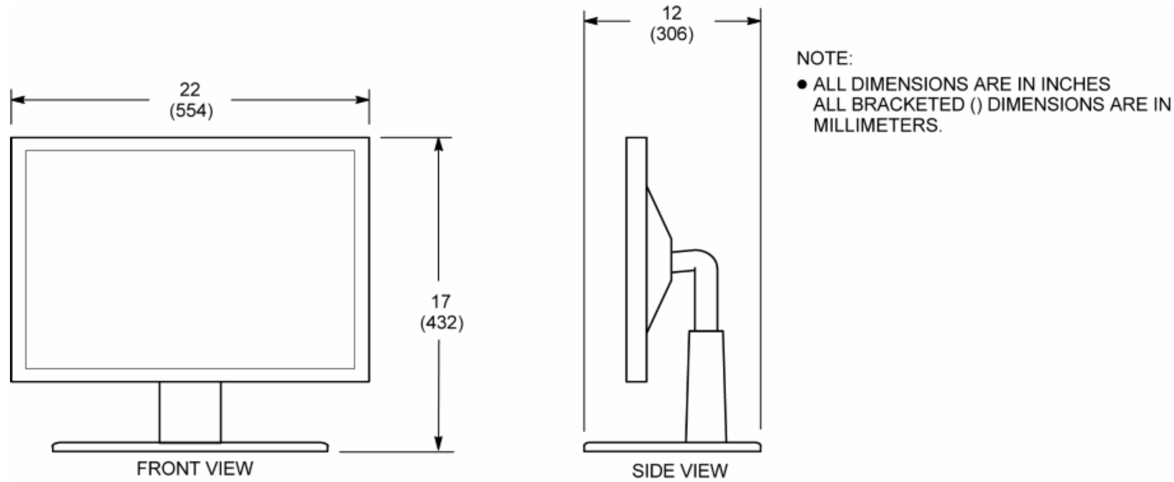
Illustration 5-2: Global Operator Cabinet (GOC)



1.3 Host Display

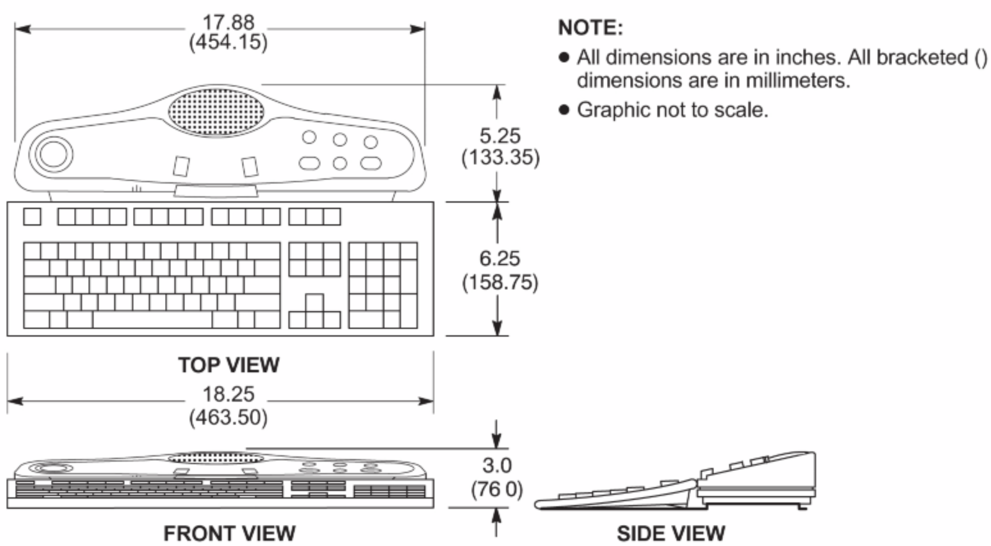
1. Weight 26 lbs (11.8 kg)
2. Magnetic Field Limit: 50 Gauss (5 mT)

Illustration 5-3: Host Display



1.4 Host Keyboard

Illustration 5-4: Host Keyboard

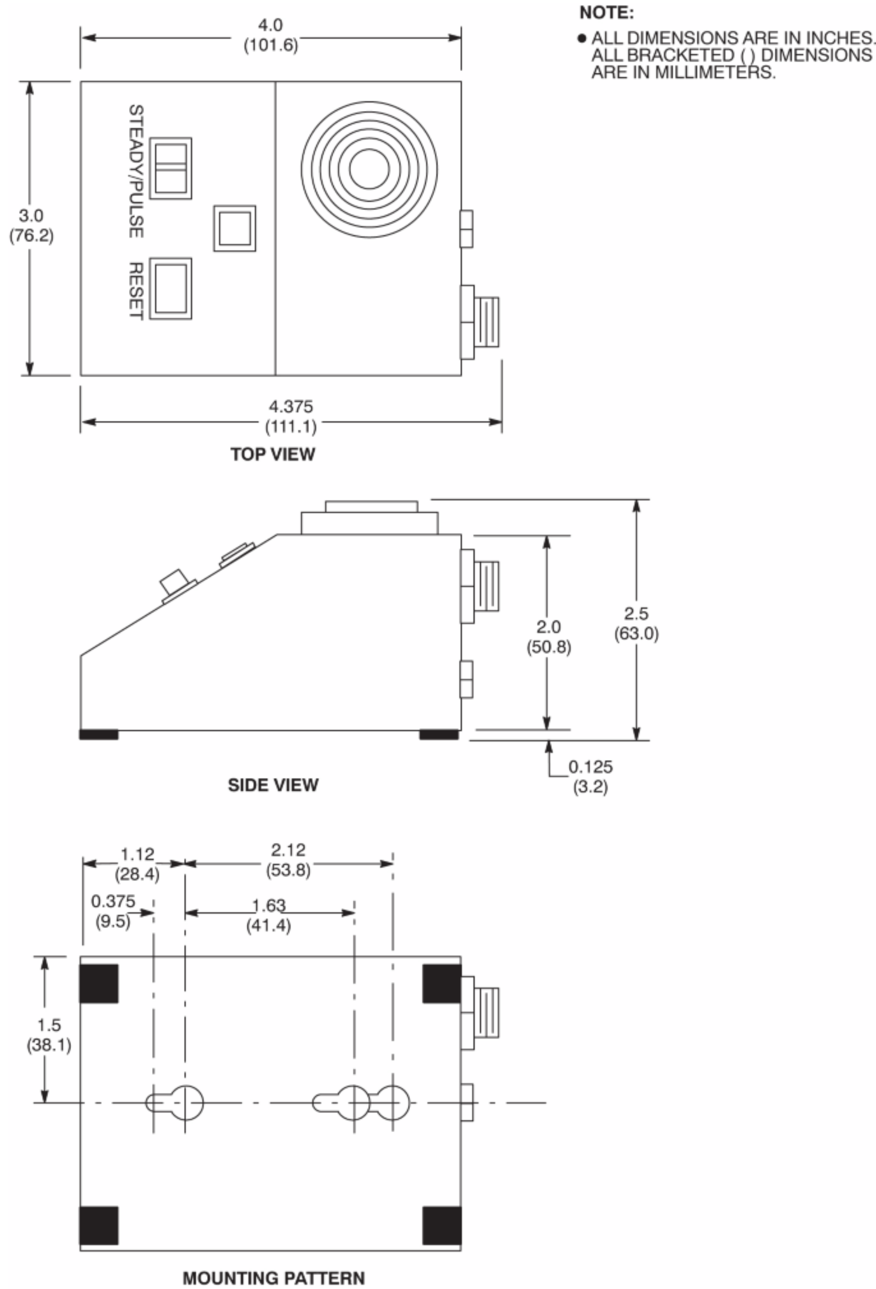


1.5 Pneumatic Patient Alert

The Pneumatic Patient Alert system allows the patient to contact the operator. The Control Box audible and visual alarm will be activated by the patient squeeze bulb which is located on the Magnet Enclosure and connected by pneumatic tubing through the Penetration Panel to the Control Box.

1. Weight 0.5 lbs (0.2 kg)
2. Magnetic Field Limit: 50 Gauss (5 mT)
3. The Control Box must be mounted within sight of operator and within 5 ft. (1.5 m) of an electrical outlet

Illustration 5-5: Pneumatic Patient Alert (PA)



2 Oxygen Monitor (OXY) Specifications

The Oxygen Monitor system consists of the Oxygen Monitor, the Remote Oxygen Sensor Module, and interconnects through the Secondary Penetration Wall (SPW). The Oxygen Monitor alarm is located near the Operator Workspace is activated by the Remote Oxygen Sensor Module in the Magnet Room.

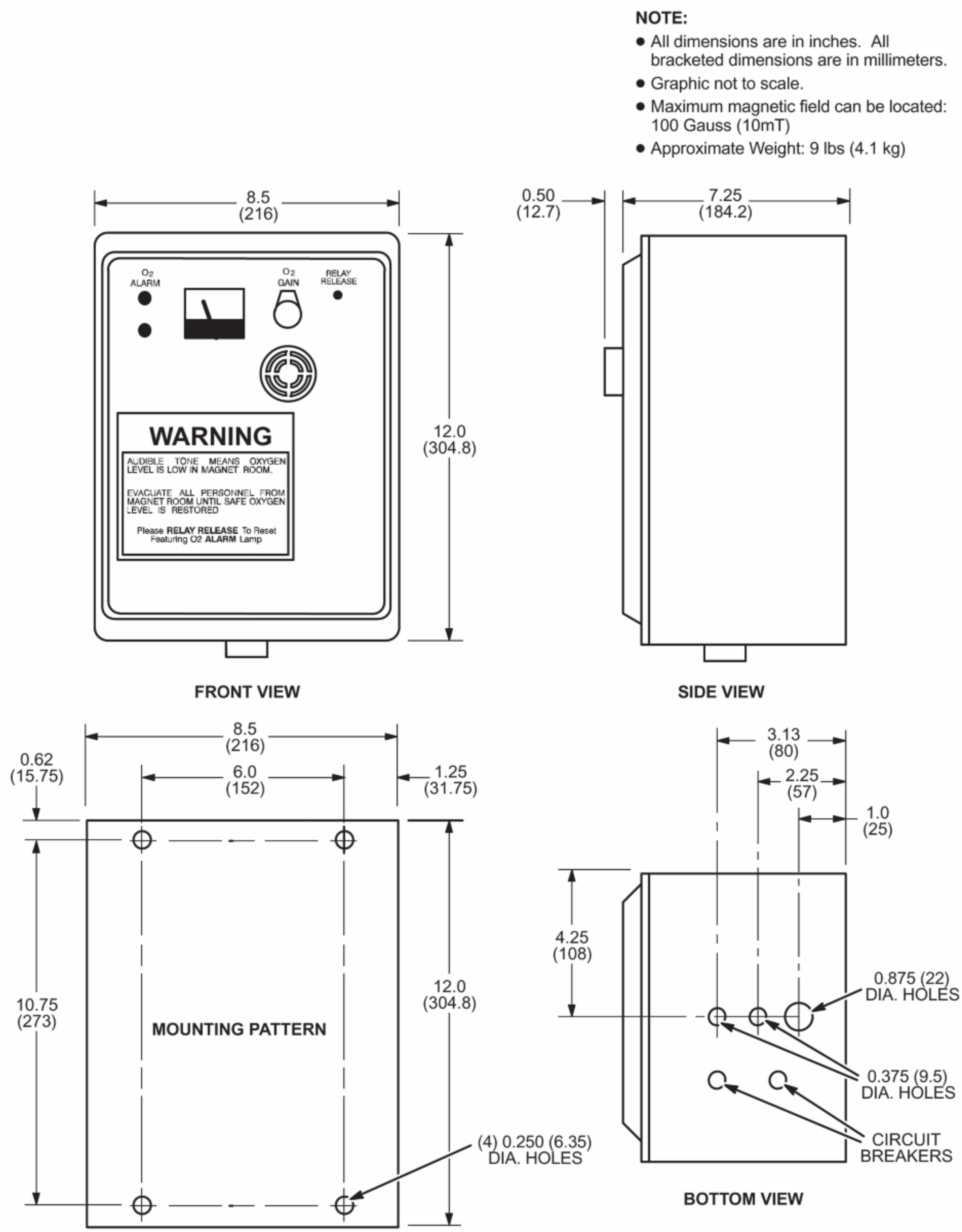
2.1 Oxygen Monitor (OXY) Requirements

The Oxygen Monitor requires facility supplied power

Table 5-1: Oxygen Monitor Facility Power Requirements

Parameter	Requirements	
Voltage / Frequency	100-120 VAC	50/60 Hz
	200-220 VAC	50/60 Hz
Phase	1	
Maximum Amps	3.0	
Connection type	Hard wired in unit	

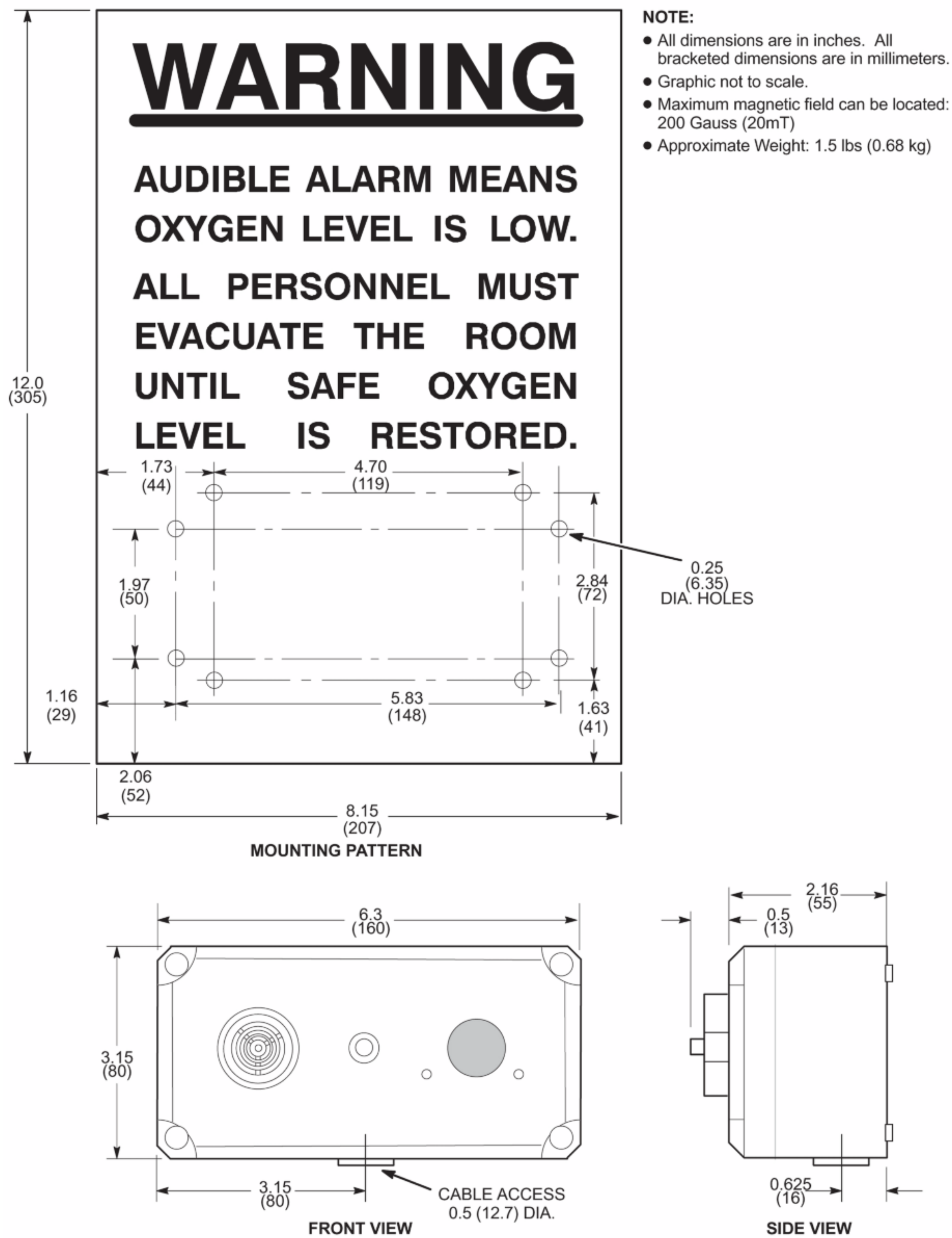
Illustration 5-6: Oxygen Monitor (OXY)



2.2 Oxygen Monitor Sensor

The Remote Oxygen Sensor Module must be mounted approximately 60 in. (1524 mm) above the Magnet Room floor near the front of the Magnet Enclosure.

Illustration 5-7: Oxygen Monitor Sensor



Chapter 6 MR System Interconnects

1 MR System Interconnects Specifications

1.1 Component Designator Definitions

GE Healthcare uses Component Designators to identify system components. All subsystem cabinets and other components are referred to by their component designators in the Interconnect Data diagrams and tables.

Table 6-1: MR System Component Designators

Component Designator	Description
CRY	Cryocooler Compressor Cabinet
E01, E02, etc.	Emergency Off Buttons
MDP	Main Disconnect Panel
HEC	Heat Exchanger Cabinet
MAG	Magnet and Enclosure (all magnet enclosure components in Magnet Room)
Modem	Modem for Magnet Monitor
MON	Magnet Monitor
MRU	Magnet Rundown Unit
OW	Operator Workstation
PA1	Pneumatic Patient Alert Control Box
PDU	Power Distribution Unit (PDU) is a module in the PGR cabinet
PED	Magnet Rear Pedestal
PEN	Penetration Panel Cabinet
PGR	Power Gradient RF Cabinet
PT	Patient Transport Table
DS, DS1	Door Switch
SPW	Secondary Pen Wall

Table 6-2: MR System Options Component Designators

Component Designator	Description
BW	Brainwave Lite Cabinet
OXY	Oxygen Monitor
OM2	Remote Oxygen Sensor Module
MRE	Magnetic Resonance Elastography

1.2 Usable Cable Lengths

Table 6-3: Usable Cable Lengths

Point A	Point B	Site Option: Short	Site Option: Long
		in. (mm)	
Equipment Room			
CRY	Magnet Monitor	370.1 (9400)	
Magnet Monitor	SPW, bottom edge	661.4 (16800)	
HEC, top panel	CRY	354.3 (9000)	
HEC, top panel	Customer-Supplier Network	1102.4 (28000)	
PEN cabinet, top panel	GOC, rear panel	141.7 (29000)	
PEN cabinet, top panel	Magnet Monitor	645.7 (16400)	
PEN Ground stud	RF common ground stud	86.6 (2200)	
SPW Ground stud	RF common ground stud	85.6 (2200)	
PGR, top panel	GOC, rear panel	1133.9 (28800)	
PGR, top panel	HEC, top panel	346.5 (8800)	
PGR, top panel	Magnet room door switch	960.6 (24400)	
PGR, top panel	PEN cabinet, top panel	370.1 (9400)	645.7 (16400)
PGR, top panel	SPW, bottom edge	385.8 (9800)	661.4 (16800)
PGR, top panel	RF common ground stud	362.2 (9200)	637.8 (16200)
SPW, bottom edge	CRY	551.2 (14000)	
SPW, bottom edge	E-off switch, Control room or Equipment room	385.8 (9800)	661.4 (16800)
SPW, bottom edge	GOC, rear panel	1149.6 (29200)	
HEC, top panel	SPW, bottom edge	244 (6200)	677 (17200)
Magnet Room			
PEN panel, bottom edge	MAG, gradient cable clamp block	354.3 (9000)	511.8 (13000)
SPW, bottom edge	MAG, gradient cable clamp block	354.3 (9000)	511.8 (13000)
SPW, bottom edge	E-off switch, Magnet Room	1173.2 (29800)	
GOC, rear panel	MAG, gradient cable clamp block	1496.1 (38000)	1653.5 (42000)
MRU	MAG, gradient cable clamp block	972.4 (24700)	
RF common ground stud	MAG, gradient cable clamp block	393.7 (10000)	551.2 (14000)

1.3 Brainwave Option

Table 6-4: Brainwave Option Usable Cable Lengths

Cable Part number	Point A	Point B	Site Option A: Short ER, Short SR	Site Option B: Long ER, Short SR	Site Option C: Short ER, Long SR
			in. (mm)		
	PEN Wall/Cabinet	Brainwavew Cabinet			
LG408	Empty 9 pin D-sub	Lumina Controller	720 (18,288)		
LU001-60	J16 in PEN Cabinet	Lumina Controller	720 (18,288)		

1.4 Magnetic Resonance Elastography (MRE) Option

Table 6-5: MRE Option Usable Cable Lengths

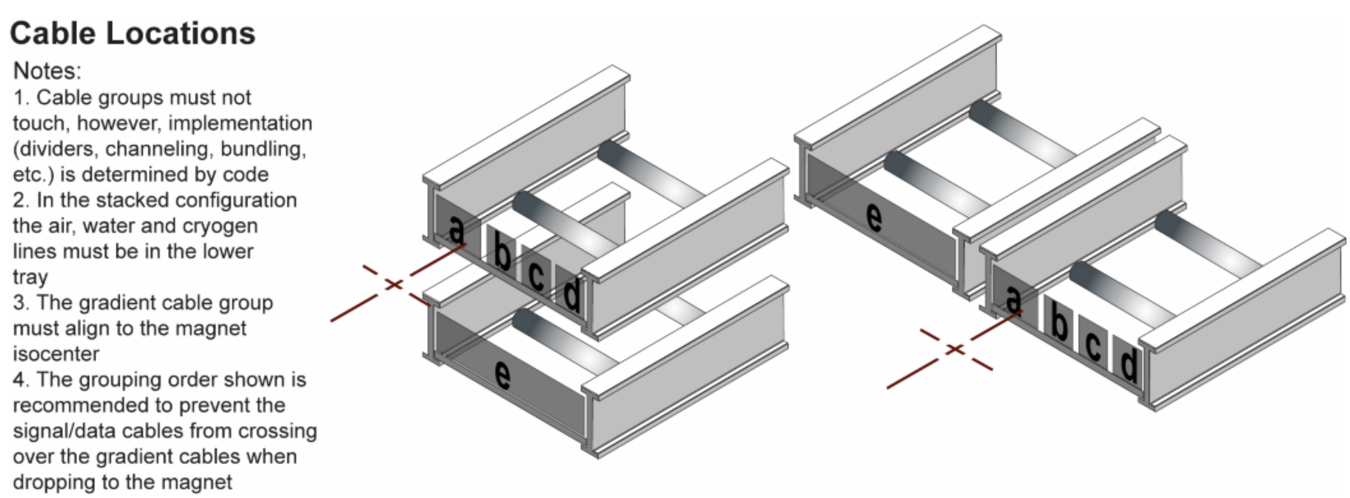
Cable Part number	Point A	Point B	Site Option A: Short ER, Short SR	Site Option B: Long ER, Short SR	Site Option C: Short ER, Long SR
			in. (mm)		
1 in (2.54 mm) Tubing	Resoundant Active Driver	Magnet (Isoceter)	Nominal 288 (7315) Maximum 396 (10058)		
BNC	Resoundant Active Driver	PEN Cabinet J6	600 (15,240)		
Ethernet	Resoundant Active Driver	Ethernet Hub in PGR	600 (15,240)		
Power	Resoundant Active Driver	Customer Supplied Outlet	60 Hz: 240 (6096) 50 Hz: 300 (7620)		

2 MR System Interconnects Routing Requirements

2.1 General Requirements

1. The customer is responsible for the purchase and installation of all cable support mechanisms
2. Any type of cable support may be used, such as Ladder or Channel style cable trays or Unistruts, provided the cable trays meets all MR system requirements (including all local and national codes)
3. All cable support must be nonferrous (e.g., composites or aluminum)
4. The distance between cable supports must be less than 12 in. (305 mm). For example, the distance between rungs on a ladder tray, or the distance from the end of a cable tray to a final non-ferrous Unistrut must be 12 in. (305 mm) or less)
5. Two cable supports must be used, each at least 18 in. (457 mm) wide
6. The cable supports must have a minimum cable bend radius of 13 in. (330 mm) to accommodate gradient cables (vertical or horizontal bends)
7. Cable supports may be stacked or side-to-side
8. Air, water, and gas lines must be run in the lower support if stacked (see Illustration 6-1)
9. The following cable groups must be routed in separate sections:
    a. Gradient and RF common ground cables
    b. Coax, RF, and AC power cables with jacket rating of 600V and above
    c. Data and fiber optic and 300V coax or RF clock cables
    d. 300V signal, 300V power, and 300V power/signal cables
    e. Air, water, and cryogen lines

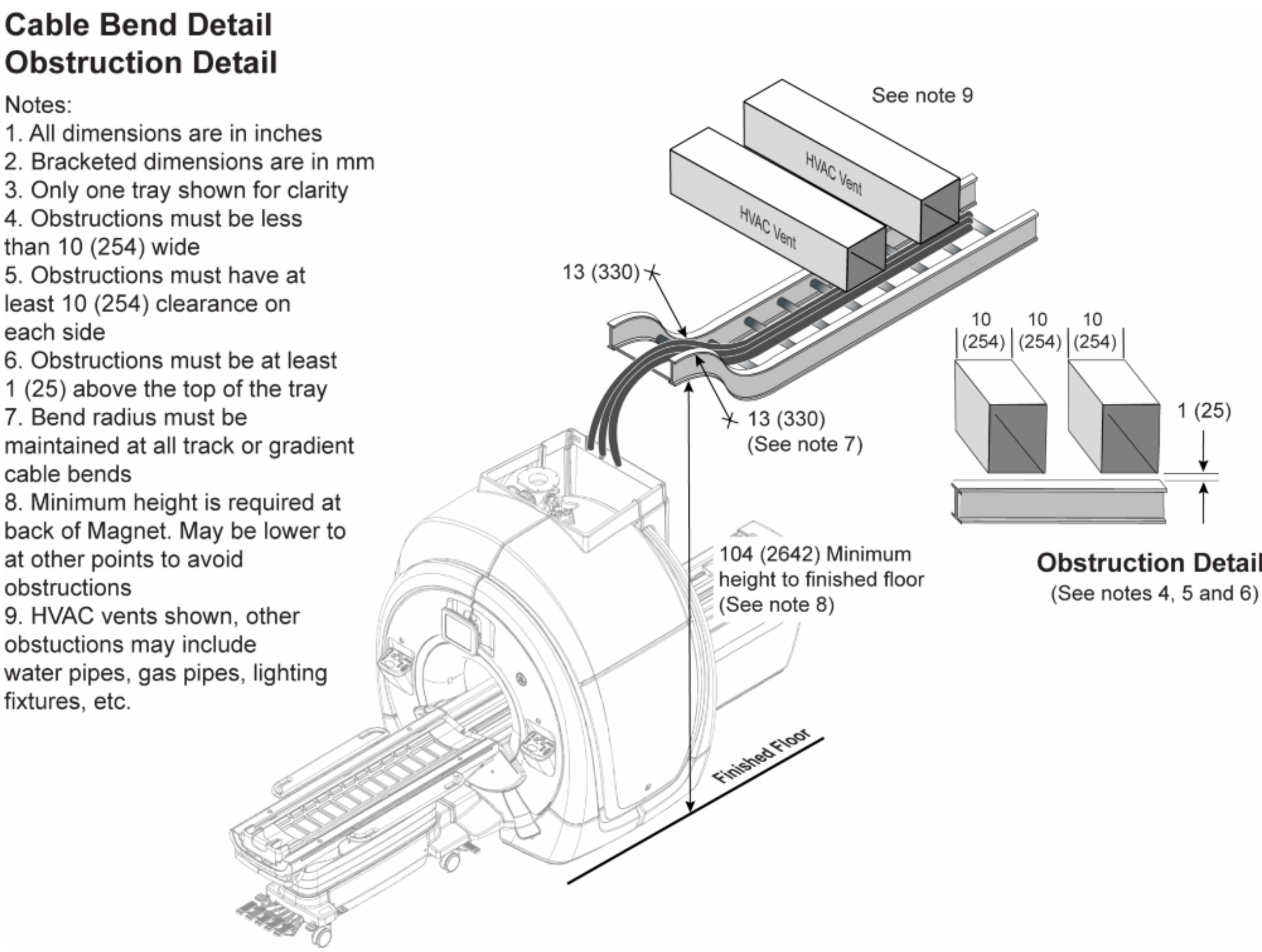
Illustration 6-1: Cable Groupings



10. The top of the cable support must be less than 128 in. (3251 mm) above the finished floor

11. Cables must be accessible on at least one side and require a minimum of 10 in. (254 mm) from the top of the support to any object above the support (obstructions) except as noted in the following requirement
12. Obstructions up to 10 in. (254 mm) wide are allowed 1 in. (25.4 mm) above the top of the cable support with 10 in. (254 mm) of clear space on either side of the obstruction (see Illustration 6-2for an obstruction example in the Magnet room)

Illustration 6-2: Cable Bends and Obstructions



2.2 Magnet Room Requirements

Illustration 6-3: Cable Track Requirements

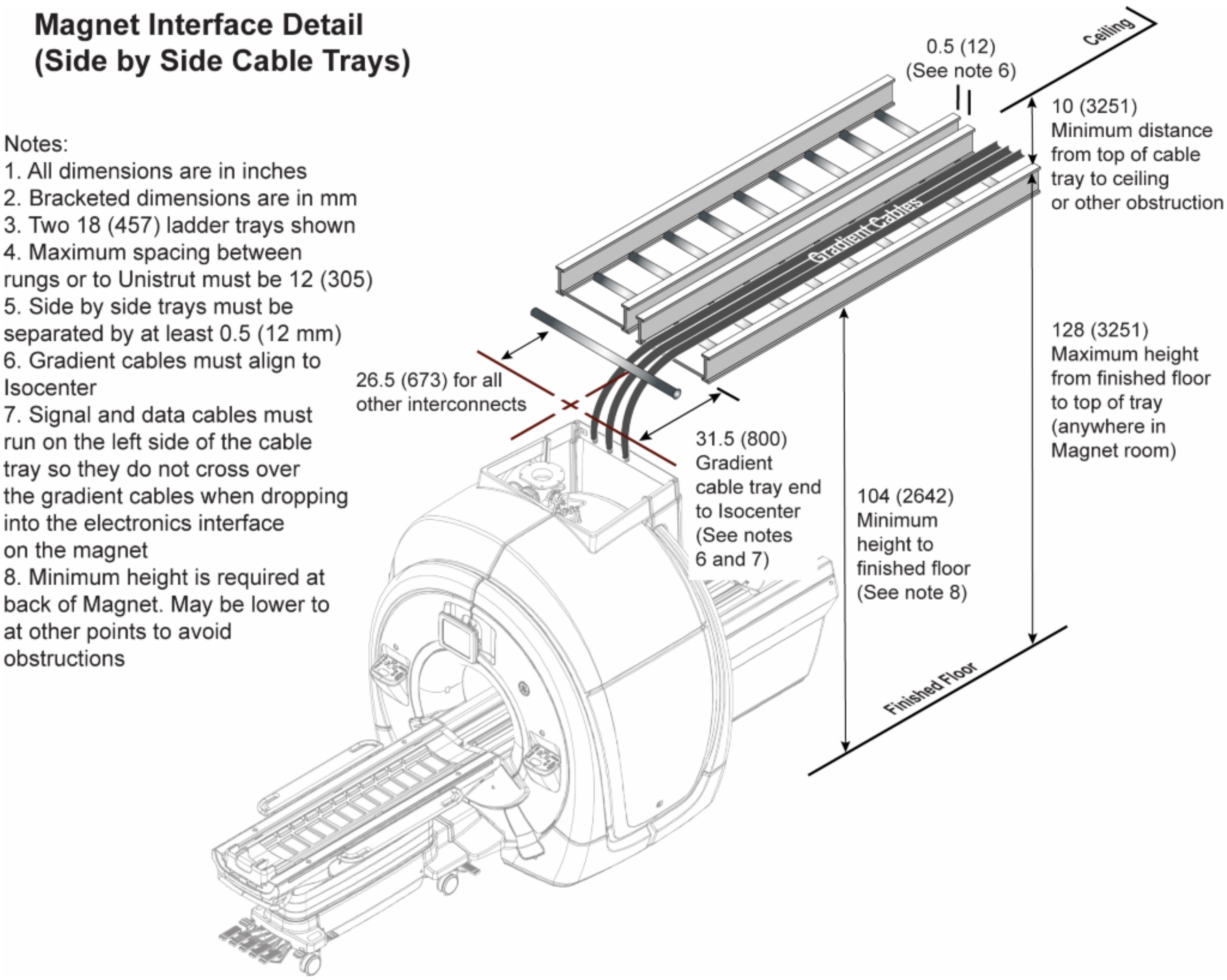
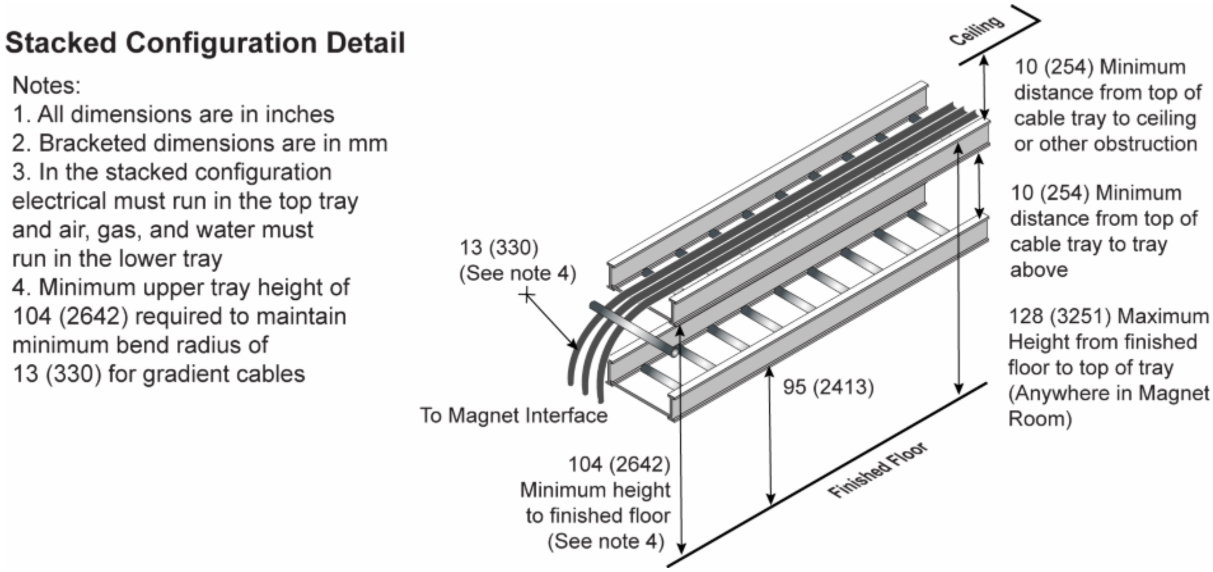


Illustration 6-4: Stacked Cable Trays

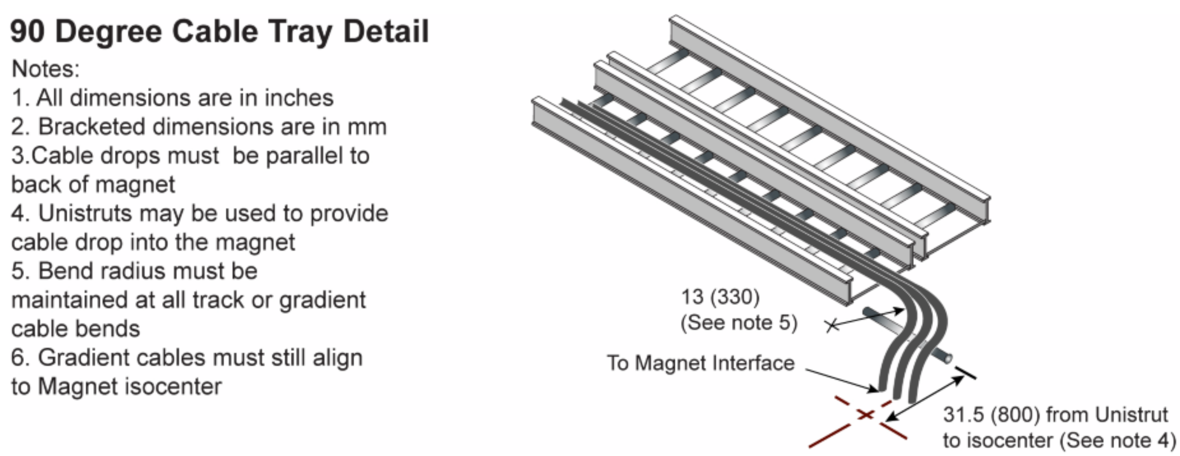


1. Installation and routing of cable supports must be coordinated with the RF shield vendor
2. Side-to-side supports in the Magnet room must be separated by at least 0.5 in. (12 mm) to prevent RF broadband noise caused by metal-to-metal sidewall contact
3. Each cable support mechanism must support a weight of at least 50 lbs/ft (74.8 kg/m)

   NOTE: If stacked, each cable support mechanism must support the weight of both cable trays: i.e., 100 lbs/ft (149.6 kg/m)

4. Cable supports must not be routed within the exclusion zone over the magnet (see Chapter 2, MR Suite Minimum Room Size Requirements for ceiling exclusion area)
5. Supports for all other cables and hoses must end at the back of the magnet 31.5 in. (800 mm) from geometric isocenter

Illustration 6-5: 90 Degree Magnet Interface



   Supports for all other cables must end at the back of the magnet 26.5 in. (673 mm) from geometric isocenter

6. Cable supports must have a minimum height of 104 in. (2642 mm) at the back of the magnet

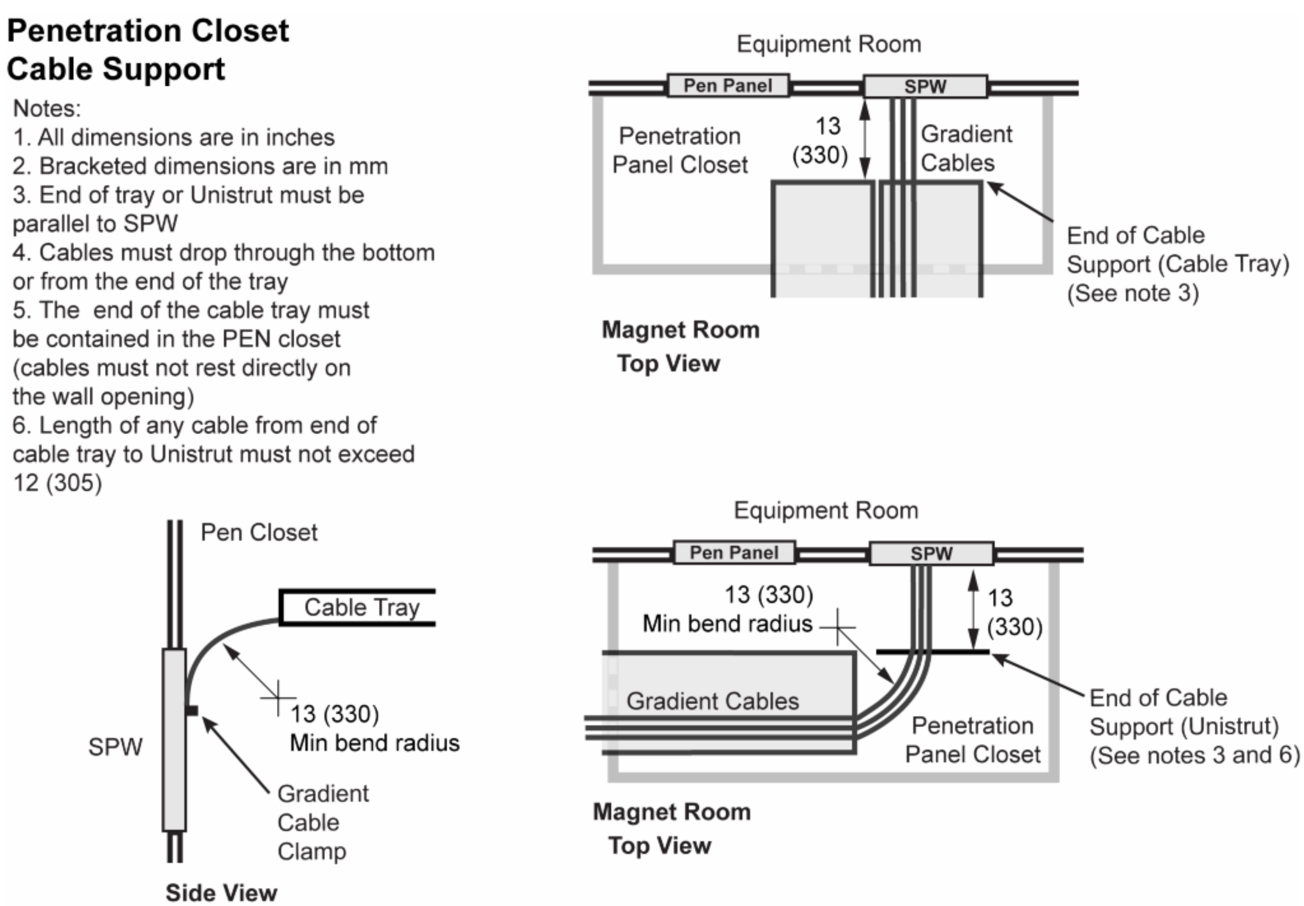
NOTE: Supports may be lower at other points along the route to clear obstructions as long as all other requirements are met

7. Ceiling grid work, medical gas lines, lighting fixtures, etc. must not touch MR system cabling or cable supports
8. Excess cable length in the Magnet room must be stored in either:
   a. Penetration Panel closet
   b. Magnet room cable supports (excess cable must be at least 36 in. (914 mm) from the magnet end of the support

2.3 Penetration Panel Closet Requirements

1. The end of the cable support must be contained within the Penetration Panel closet (see Illustration 6-6
2. The end of the gradient cable support must be parallel to the Secondary Pen Wall (SPW)
3. The gradient cable support height and distance from the SPW must support a minimum cable bend radius of 13 in. (330 mm) to accommodate gradient cables

Illustration 6-6: Penetration Closet Cable support



2.4 Equipment Room Requirements

1. All equipment interconnects must route overhead (except helium hoses)
2. Cables/hoses must drop through the bottom or off the end of the cable support directly to the top of the cabinets (see individual components in Chapter 4 for height requirements)
3. Cable supports do not have minimum height restrictions except above Equipment room components (to maintain the 13 in. (330 mm) bend radius drop to the cabinet)
4. The end of the gradient cable support must be parallel to the Secondary Pen Wall (SPW)
5. The gradient cable support height and distance from the SPW must support a minimum cable bend radius of 13 in. (330 mm) to accommodate the gradient cable bend radius
6. Excess cable length must be stored in the Equipment room
7. For multiple MR system installations, cables from different MR systems must not share the same cable support

3 MR System Cable Specifications

MR450w cables are marked with an X in the column titled 450w. The other cables are not used with the MR450w system.

Illustration 6-7: System Cable List (Page 1)

450	750	450w	Part Number	Description	Connector Size/dia in	Connector Size/dia mm	Cable Diameter in	Cable Diameter mm	Bend Radius in	Bend Radius mm	Conductors	AWG	Certification	Volt Rating (volts)	Temp Rating (C)	Notes
X	X	X	2200835	Run E0009, HEC to CRY, INPUT POWER, SUMITOMO CSW-71D, 10000mm	1.5	38	0.8	21	7.0	178	4	12	LFNC	600	105°	Four 12AWG wires in conduit
X	X	X	2155316	Run 623, CRY to SPW, COLD HEAD CONTROL,LCC, 15000mm	1.25	32	0.3	7	7.0	178	4	16	CM, FT4	300	90°	
X	X	X	2218292	Run 624, SPW to MAG, COLD HEAD CONTROL,LCC, 15000mm	1.25	32	0.3	7	7.0	178	4	16	CM, FT4	300	90°	
X	X	X	5191457	Run M3030, SPW-J115 to E-OFF, 30000mm	1.5	38	0.3	8	6.0	152	9	22	CL3, FT4	300	80°	
X	X		2384104-2	Run 1152, PP1-A5-P1 TO MG2A12A3, 15240mm	1.75	44	0.6	15	9.0	229	13	16	CL3, FT4	300	105°	Higher order shim cable (option)
X	X	X	5166522-2	Run E3008, PGR-J4 to PEN-J9, CAN,10000mm	1.5	38	0.3	8	6.0	152	9	22	CL3, FT4	300	80°	
X	X	X	5166522-3	Run E3008, PGR-J9 to PEN-J9, CAN,17000mm	1.5	38	0.3	8	6.0	152	9	22	CL3, FT4	300	80°	
X	X	X	5330926-2	Run M1302, PEN-J29 to MAG-TDM-J11, Receiver Clock, Twinax, 11000mm	1	25	0.3	8	5.0	127	2	20	CL2, FT4	300	75°	twinaxial cable
X	X	X	5330926-6	Run M1302, PEN-J29 to MAG-TDM-J11, Receiver Clock, Twinax, 15000mm	1	25	0.3	8	5.0	127	2	20	CL2, FT4	300	75°	twinaxial cable
X	X	X	5330926-3	Run M1304, PEN-J30 to PED-HUB-SLOT11-J17, Rx LO - Exciter Reference Clock, Twinax, 13500mm	1	25	0.3	8	5.0	127	2	20	CL2, FT4	300	75°	twinaxial cable
X	X	X	5330926-7	Run M1304, PEN-J30 to PED-HUB-SLOT11-J17, Rx LO - Exciter Reference Clock, Twinax, 17500mm	1	25	0.3	8	5.0	127	2	20	CL2, FT4	300	75°	twinaxial cable
X	X	X	5167907-2	Run E3011, PGR-J2 to OW1-Host, Ethernet, 30000mm	0.63	16	0.3	6	5.0	127	8	26	CMP	300	75°	
X	X	X	5167907-4	Run E3013, PGR-J6 to HEC-CAT 5, Cooling Control Ethernet,10000mm	0.63	16	0.3	6	5.0	127	8	26	CMP	300	75°	
X	X	X	5167907-5	Run E3034 MON-J5 to customer-supplied Network,30000mm	0.63	16	0.3	6	5.0	127	8	26	CMP	300	75°	
X			5168163	Run E1001, PGR-J19 to SPW-J106, 1.5T RF Transmit, 10327mm ref.	2.85	72	0.9	23	9.0	229	1	N/A	CMR, FT4	5000	85°	LMR-900 coaxial cable
X			5168163-2	Run M1001, SPW-J106 to RUN M1319, 1.5T RF Transmit, 10327 mm ref.	2.85	72	0.9	23	9.0	229	1	N/A	CMR, FT4	5000	85°	LMR-900 coaxial cable
X			5168163-3	Run M1001, SPW-J106 to RUN M1319, 1.5T RF Transmit, 14457mm ref.	2.85	72	0.9	23	9.0	229	1	N/A	CMR, FT4	5000	85°	LMR-900 coaxial cable
X			5168163-4	Run E1001, PGR-J19 to SPW-J106, 1.5T RF Transmit, 16523mm ref.	2.85	72	0.9	23	9.0	229	1	N/A	CMR, FT4	5000	85°	LMR-900 coaxial cable
		X	5344701	Run M1001, SPW-J106 to MAG-HYB-J1, 1.5T RF Body Transmit, 12394mm ref. Aluminum braid shield.	2.85	72	0.9	23	9.0	229	1	N/A	CMR, FT4	5000	85°	LMR-900 coaxial cable
		X	5344701-2	Run M1001, SPW-J106 to MAG-HYB-J1, 1.5T RF Body Transmit, 16525mm ref. Aluminum braid shield.	2.85	72	0.9	23	9.0	229	1	N/A	CMR, FT4	5000	85°	LMR-900 coaxial cable
		X	5330729-5	Run E1001, PGR-J19 to SPW-J106, 1.5T RF Transmit, 10327mm ref. Aluminum braid shield.	2.85	72	0.9	23	9.0	229	1	N/A	CMR, FT4	5000	85°	LMR-900 coaxial cable

Illustration 6-8: System Cable List (Page 2)

					Connector Size/dia		Cable Diameter		Bend Radius							
450	750	450w	Part Number	Description	in	mm	in	mm	in	mm	Conductors	AWG	Certification	Volt Rating (volts)	Temp Rating (C)	Notes
		X	5330729-6	Run E1001, PGR-J19 to SPW-J106, 1.5 RF Transmit, 16523mm ref. Aluminum braid shield.	2.85	72	0.9	23	9.0	229	1	N/A	CMR, FT4	5000	85°	LMR-900 coaxial cable
X	X	X	5168733	Run E0003, PGR-J102 to OW-PDM-J1, Host Power, 30000mm	1.4	36	0.5	11	6.0	152	3	10	UL AWM 2587, FT4	600	90°	
X	X	X	5168845	Run E3028, HEC-PLC-RS232 to PGR-J3, Cooling Control Communication, 10000mm	0.63	16	0.3	6	6.0	152	8	26	CM, FT4	300	75°	
X	X	X	5168970	Run E3030, SPW-J115 to E-Off SW, E-off,10000mm	1.5	38	0.3	8	5.0	127	2	22	CMG, FT4	300	105°	
X	X	X	5168970-4	Run E3014, PGR-J20 to RF Door SW, E-Stop, 25000mm	1.5	38	0.3	8	5.0	127	2	22	CMG, FT4	300	105°	
X	X	X	5168970-5	Run E3030 E-Off Switch to SPW-J115,17000mm	1.5	38	0.3	8	5.0	127	2	22	CMG, FT4	300	105°	
X	X	X	5169207-2	Run E0004, PGR-J16 to PEN-J1,PEN Power, 10000mm	1.75	44	0.6	14	6.0	152	5	10	UL AWM 2587, FT4	600	90°	
X	X	X	5169207-4	Run E0004 PGR-J16 to Pen-J1,Pen Power,17000mm	1.75	44	0.6	14	6.0	152	5	10	UL AWM 2587, FT4	600	90°	
X	X	X	5169227-10	Run M3031, SPW-J118 to MAG-J1, Console Intercom, 10000mm	2.5	64	0.4	11	6.0	152	25	22	CL3, FT4	300	80°	
X	X	X	5169227-11	Run M3031, SPW-J118 to MAG-J1, Console Intercom, 14000mm	2.5	64	0.4	11	6.0	152	25	22	CL3, FT4	300	80°	
X	X	X	5169227-2	Run E3031, SPW-J118 to OW-J7, Patient Intercom, 30000mm	2.5	64	0.4	11	6.0	152	25	22	CL3, FT4	300	80°	
X	X	X	5169227-5	Run M3312 PEN-J41 to MAG-J6, PAC Power, 10000mm	2.5	64	0.4	11	6.0	152	25	22	CL3, FT4	300	80°	
X	X	X	5169227-7	Run M3312 PEN-J41 to MAG-J6, PAC Power, 14000mm	2.5	64	0.4	11	6.0	152	25	22	CL3, FT4	300	80°	
X	X	X	5329990	Run M3311 PEN-J36 to PED-MTR-J1, Long Drive Power, 15500mm	2.5	64	0.4	10	3.9	99	6	4/C 14AWG + 2/C 22AWG	CMG, FT4	300	80°	
X	X	X	5329990-2	Run M3311 PEN-J36 to PED-MTR-J1, Long Drive Power, 19500mm	2.5	64	0.4	10	3.9	99	6	4/C 14AWG + 2/C 22AWG	CMG, FT4	300	80°	
X	X	X	5169277	Run E3006, PGR-J5 to PEN-J14, HART,10000mm	1.5	38	0.3	8	6.0	152	9	22	CL3, FT4	300	90°	
X	X	X	5169277-12	Run M3022, SPW-J116 to MAG-P403, 14000 mm	1.5	38	0.3	8	6.0	152	9	22	CL3, FT4	300	90°	
X	X	X	5169277-2	Run E3015, PGR-J17 to OW-FJ6, E-stop, 30000mm	1.5	38	0.3	8	6.0	152	9	22	CL3, FT4	300	90°	
X	X	X	5169277-4	Run E3017, PEN-J10 to OW-FJ5, E-stop, 30000mm	1.5	38	0.3	8	6.0	152	9	22	CL3, FT4	300	90°	
X	X	X	5169277-9	Run E3006 PGR-J5 to Pen-J14,17000 mm	1.5	38	0.3	8	6.0	152	9	22	CL3, FT4	300	90°	
X	X	X	5330927-6	Run M3316, PEN-J34 to PED-HUB-SLOT11-J10, TR_DD Unblank, 13500mm.	1.5	38	0.3	8	6.0	152	9	22	CL3, FT4	300	90°	
X	X	X	5330927-10	Run M3316 Pen-J34 to PED-HUB-SLOT11-J10,17500mm.	1.5	38	0.3	8	6.0	152	9	22	CL3, FT4	300	90°	
X	X	X	5330927-7	Run M3315, PEN-J54 to PED-TIF-J4 , Hall's Signal, 14500mm.	1.5	38	0.3	8	6.0	152	9	22	CL3, FT4	300	90°	

Illustration 6-9: System Cable List (Page 3)

					Connector Size/dia		Cable Diameter		Bend Radius							
450	750	450w	Part Number	Description	in	mm	in	mm	in	mm	Conductors	AWG	Certification	Volt Rating (volts)	Temp Rating (C)	Notes
X	X	X	5330927-11	Run M3315 Pen-J54 to PED-TIF-J4,18500mm.	1.5	38	0.3	8	6.0	152	9	22	CL3, FT4	300	90°	
X	X	X	5169368	Run E3009 PGR-J8 to Pen-J3,10000 mm	3	76	0.5	13	6.0	152	37	22	CL3, FT4	300	80°	
X	X	X	5169368-2	Run E3009 PGR-J8 to Pen-J3,17000 mm	3	76	0.5	13	6.0	152	37	22	CL3, FT4	300	80°	
X	X	X	5169404	Run E3018, PEN-J12 to OW-FJ7, HART-RS422, 30000mm	1.75	44	0.3	9	6.0	152	15	22	CL3, FT4	300	80°	
X	X	X	5169404-2	Run E3002, PGR-J103 to PEN-J11, E-Stop, 10000mm	1.75	44	0.3	9	6.0	152	15	22	CL3, FT4	300	80°	
X	X	X	5169404-3	Run M3314 PEN-J42 to MAG-J2, LCD Power, 10000mm	1.75	44	0.3	9	6.0	152	15	22	CL3, FT4	300	80°	
X	X	X	5169404-4	Run M3314 Pen-J42 to Mag-J2,LCD Power, 14000 mm	1.75	44	0.3	9	6.0	152	15	22	CL3, FT4	300	80°	
X	X	X	5169404-5	Run E3002 PGR-J103 to Pen-J11,17000 mm	1.75	44	0.3	9	6.0	152	15	22	CL3, FT4	300	80°	
X	X	X	5169404-7	Run E3020 Pen-J13 to Mon-J10,17000mm	1.75	44	0.3	9	6.0	152	15	22	CL3, FT4	300	80°	
X	X	X	5169588	Run M3310 PEN-J45 to PED-HUB-SLOT12-J4, RF Power, 13500mm	3.5	89	0.4	11	6.8	173	25	22	CL3, FT4	300	80°	
X	X	X	5169588-2	Run M3310 PEN-J45 to PED-HUB-SLOT12-J4, RF Power, 17500mm	3.5	89	0.4	11	6.8	173	25	22	CL3, FT4	300	80°	
	X		5169804-11	Run E1006, PGR-J9 to SPW-J107, Dummy Load SAR Monitoring, 10000mm	0.63	16	0.2	5	2.0	51	1	N/A	CMR, FT4	1000	100°	LMR-195 coaxial cable
	X		5169804-12	Run E1015, PGR-J10 to SPW-J108, Dummy Load SAR Monitoring, 10000mm	0.63	16	0.2	5	2.0	51	1	N/A	CMR, FT4	1000	100°	LMR-195 coaxial cable
	X		5169804-20	Run M1006, SPW-J107 to PED-DUM-J13, Dummyload, 3T, 13500mm	0.63	16	0.2	5	2.0	51	1	N/A	CMR, FT4	1000	100°	LMR-195 coaxial cable
	X		5169804-21	Run M1015, SPW-J108 to PED-DUM-J14, Dummyload, 3T, 13500mm	0.63	16	0.2	5	2.0	51	1	N/A	CMR, FT4	1000	100°	LMR-195 coaxial cable
X	X	X	5169804-25	Run E1005, PGR-J11 to PEN-J15, Tx Output, 17000mm	0.63	16	0.2	5	2.0	51	1	N/A	CMR, FT4	1000	100°	LMR-195 coaxial cable
	X		5169804-26	Run E1006, PGR-J9 to SPW-J107, Dummy Load SAR Monitoring, 17000mm	0.63	16	0.2	5	2.0	51	1	N/A	CMR, FT4	1000	100°	LMR-195 coaxial cable
	X		5169804-27	Run E1015, PGR-J10 to SPW-J108, Dummy Load SAR Monitoring, 17000mm	0.63	16	0.2	5	2.0	51	1	N/A	CMR, FT4	1000	100°	LMR-195 coaxial cable
	X		5169804-29	Run M1006, SPW-J107 to PED-DUM-J13, Dummyload, 3T, 17500mm	0.63	16	0.2	5	2.0	51	1	N/A	CMR, FT4	1000	100°	LMR-195 coaxial cable
X	X	X	5169804-3	Run E1005, PGR-J11 to PEN-J15, Tx Output, 10000mm	0.63	16	0.2	5	2.0	51	1	N/A	CMR, FT4	1000	100°	LMR-195 coaxial cable
	X		5169804-30	Run M1015, SPW-J108 to PED-DUM-J14, Dummyload, 3T, 17500mm	0.63	16	0.2	5	2.0	51	1	N/A	CMR, FT4	1000	100°	LMR-195 coaxial cable
X	X	X	5329514-13	Run M1303, PEN-J32 to PED-HUB-SLOT11-J16, NB Exciter, 14500mm	0.63	16	0.2	5	2.0	51	1	N/A	CMR, FT4	1000	100°	LMR-195 coaxial cable
X	X	X	5329514-28	Run M1303, PEN-J32 to PED-HUB-SLOT11-J16, NB Exciter, 18500mm	0.63	16	0.2	5	2.0	51	1	N/A	CMR, FT4	1000	100°	LMR-195 coaxial cable
X	X	X	5169976-51	Run M3302 PEN-J40 to MAG-J4,SRI Power, 10000mm	3	76	0.5	13	6.0	152	37	22	CL3, FT4	300	80°	
X	X	X	5169976-54	Run M3302 PEN-J40 to MAG-J4,SRI Power, 14000mm	3	76	0.5	13	6.0	152	37	22	CL3, FT4	300	80°	
X	X	X	5169976-52	Run M3303 PEN-J39 to MAG-J3, MCPDB Interface, 10000mm	3	76	0.5	13	6.0	152	37	22	CL3, FT4	300	80°	

Illustration 6-10: System Cable List (Page 4)

					Connector Size/dia		Cable Diameter		Bend Radius							
450	750	450w	Part Number	Description	in	mm	in	mm	in	mm	Conductors	AWG	Certification	Volt Rating (volts)	Temp Rating (C)	Notes
X	X	X	5169976-55	Run M3303 PEN-J39 to MAG-J3, MCPDB Interface, 14000mm	3	76	0.5	13	6.0	152	37	22	CL3, FT4	300	80°	
X	X	X	5169976-53	Run M3313 PEN-J35 to MAG-J5, Dock Power, 10000mm	3	76	0.5	13	6.0	152	37	22	CL3, FT4	300	80°	
X	X	X	5169976-56	Run M3313 PEN-J35 to MAG-J5, Dock Power, 14000mm	3	76	0.5	13	6.0	152	37	22	CL3, FT4	300	80°	
	X		5170013-11	Run M1001, RUN M1319 to SPW-J106, 3.0T Body, 14457mm ref.	2.85	72	1.2	30	###	305	1	N/A	CMR, FT4	6000	85°	LMR-1200 coaxial cable
	X		5170013-3	Run E1001, PGR-J19 to SPW-J106, 3.0T Body, 10327mm ref.	2.85	72	1.2	30	###	305	1	N/A	CMR, FT4	6000	85°	LMR-1200 coaxial cable
	X		5170013-6	Run E1001, PGR-J19 to SPW-J106, 3.0T Body, 16523mm ref.	2.85	72	1.2	30	###	305	1	N/A	CMR, FT4	6000	85°	LMR-1200 coaxial cable
	X		5170013-9	Run M1001, RUN M1319 to SPW-J106, 3.0T Body, 10327mm ref.	2.85	72	1.2	30	###	305	1	N/A	CMR, FT4	6000	85°	LMR-1200 coaxial cable
X	X	X	5330930	Run M3300,PEN-J51 to MAG-TDM-J9, TDM Power, 24W7, Low-Mag, 11200mm	3	76	1	25	8.3	211	24	7/C 12AWG + 17/C 22AWG	CL2, FT4	300	105°	
X	X	X	5330930-3	Run M3300,PEN-J51 to MAG-TDM-J9, TDM Power, 24W7, Low-Mag, 15200mm	3	76	1	25	8.3	211	24	7/C 12AWG + 17/C 22AWG	CL2, FT4	300	105°	
X	X	X	5330930-2	Run M3301, PEN-J52 to MAG-TDM-J10, TDM Power, 24W7, Low-Magnetic, 11200mm	3	76	1	25	8.3	211	24	7/C 12AWG + 17/C 22AWG	CL2, FT4	300	105°	
X	X	X	5330930-4	Run M3301,PEN-J52 to MAG-TDM-J10, TDM Power, 24W7, Low-Mag, 15200mm	3	76	1	25	8.3	211	24	7/C 12AWG + 17/C 22AWG	CL2, FT4	300	105°	
X	X	X	5171659	Run M3304,PEN-J48 to PED-HUB-SLOT12-J2, RFHub Power, 13W6, 13500mm	4.25	108	0.9	23	8.0	203	12	6/C 10AWG + 6/C 22AWG	UL AWM 2464, FT4	300	105°	
X	X	X	5171659-2	Run M3304 PEN-J48 to PED-HUB-SLOT12-J2, RFHub Power, 13W6, 17500mm	4.25	108	0.9	23	8.0	203	12	6/C 10AWG + 6/C 22AWG	UL AWM 2464, FT4	300	105°	
X	X	X	5171738	Run M3308, PEN-J47 to PED-HUB-SLOT12-J6, RFHub Power, 9C4, 13500mm	4.25	108	0.8	19	7.3	185	8	4/C 10AWG + 4/C 22AWG	UL AWM 2464, FT4	300	105°	
X	X	X	5171738-2	Run M3308, PEN-J47 to PED-HUB-SLOT12-J6, RFHub Power, 9W4, 17500mm	4.25	108	0.8	19	7.3	185	8	4/C 10AWG + 4/C 22AWG	UL AWM 2464, FT4	300	105°	
X	X	X	5172414	Run M3307, PEN-J50 to PED-HUB-SLOT12-J5, RFHub Power, 21WA4, 13500mm	4.25	108	0.8	19	7.3	185	8	4/C 10AWG + 4/C 22AWG	UL AWM 2464, FT4	300	105°	
X	X	X	5172414-2	Run M3307, PEN-J50 to PED-HUB-SLOT12-J5, RFHub Power, 21WA4, 17500mm	4.25	108	0.8	19	7.3	185	8	4/C 10AWG + 4/C 22AWG	UL AWM 2464, FT4	300	105°	
X	X	X	5172502	Run M3306, PEN-J46 to PED-HUB-SLOT12-J1, RFHub Power, 17C5, 13500mm	4.25	108	0.9	23	8.0	203	12	6/C 10AWG + 6/C 22AWG	UL AWM 2464, FT4	300	105°	

Illustration 6-11: System Cable List (Page 5)

					Connector Size/dia		Cable Diameter		Bend Radius							
450	750	450w	Part Number	Description	in	mm	in	mm	in	mm	Conductors	AWG	Certification	Volt Rating (volts)	Temp Rating (C)	Notes
X	X	X	5172502-2	Run M3306, PEN-J46 to PED-HUB-SLOT12-J1, RFHub Power, 17C5, 17500mm	4.25	108	0.9	23	8.0	203	12	6/C 10AWG + 6/C 22AWG	UL AWM 2464, FT4	300	105°	
X			5172679-14	Run M1341 PEN-J73 to MAG-J18, 10000mm	0.75	19	0.2	5	2.0	51	1	N/A	CMR, FT4	1000	100°	LMR-195 coaxial cable
X			5172679-15	Run M1341 PEN-J73 to MAG-J18, 14000mm	0.75	19	0.2	5	2.0	51	1	N/A	CMR, FT4	1000	100°	LMR-195 coaxial cable
X			5172679-16	Run M1342 PEN-J75 to MAG-J19, 10000mm	0.75	19	0.2	5	2.0	51	1	N/A	CMR, FT4	1000	100°	LMR-195 coaxial cable
X			5172679-17	Run M1342 PEN-J75 to MAG-J19, 14000mm	0.75	19	0.2	5	2.0	51	1	N/A	CMR, FT4	1000	100°	LMR-195 coaxial cable
X	X		5172679-2	Run M1312 PEN-J74 to MAG-HYB-J7,10000mm	0.75	19	0.2	5	2.0	51	1	N/A	CMR, FT4	1000	100°	LMR-195 coaxial cable
X	X		5172679-3	Run M1312 PEN-J74 t0 MAG-HYB-J7,14000mm	0.75	19	0.2	5	2.0	51	1	N/A	CMR, FT4	1000	100°	LMR-195 coaxial cable
X	X		5172679-4	Run M1310 PEN-J72 to MAG-J9, 10000mm	0.75	19	0.2	5	2.0	51	1	N/A	CMR, FT4	1000	100°	LMR-195 coaxial cable
X	X		5172679-5	Run M1310 PEN-J72 to MAG-J9, 14000mm	0.75	19	0.2	5	2.0	51	1	N/A	CMR, FT4	1000	100°	LMR-195 coaxial cable
X	X		5172679-6	Run M1311 PEN-J76 to MAG-J10,10000mm	0.75	19	0.2	5	2.0	51	1	N/A	CMR, FT4	1000	100°	LMR-195 coaxial cable
X	X		5172679-7	Run M1311 PEN-J76 to MAG-J10,14000mm	0.75	19	0.2	5	2.0	51	1	N/A	CMR, FT4	1000	100°	LMR-195 coaxial cable
		X	5330932-25	Run M1312, DVw, Pen-J74 to MAG-HYB-J6,13000 mm	0.75	19	0.2	5	2.0	51	1	N/A	CMR, FT4	1000	100°	LMR-195 coaxial cable
		X	5330932-26	Run M1312, DVw, Pen-J74 to MAG-HYB-J6,17000 mm	0.75	19	0.2	5	2.0	51	1	N/A	CMR, FT4	1000	100°	LMR-195 coaxial cable
		X	5330932-4	Run M1310 PEN-J72 to MAG-J9, 10000mm	0.75	19	0.2	5	2.0	51	1	N/A	CMR, FT4	1000	100°	LMR-195 coaxial cable
		X	5330932-5	Run M1310 PEN-J72 to MAG-J9, 14000mm	0.75	19	0.2	5	2.0	51	1	N/A	CMR, FT4	1000	100°	LMR-195 coaxial cable
X	X	X	5330929	Run M3309, SPW-J123 to PED-HUB-SLOT_11-J9, Transmit switch control, 13500mm	1.5	38	0.3	8	3.0	76	7	22	CMG, FT4	300	80°	
X	X	X	5330929-2	Run M3309, SPW-J123 to PED-HUB-SLOT_11-J9, Transmit switch control, 17500mm	1.5	38	0.3	8	3.0	76	7	22	CMG, FT4	300	80°	
X	X	X	5172921	Run E3022,MON-J7 to SPW-J116, Instrumentation Box, 17000mm	2.5	64	0.3	8	6.0	152	6	22	CMG, FT4	300	80°	
X	X		5173115	Run M1305, SPW-J122 to MAG-J14, P1 RF Transmit, 10218mm	1	25	0.6	15	6.0	152	1	N/A	CMR, FT4	4000	85°	LMR-600 coaxial cable
X	X		5173115-2	Run M1305, SPW-J122 to MAG-J14, P1 Transmit, 14305mm	1	25	0.6	15	6.0	152	1	N/A	CMR, FT4	4000	85°	LMR-600 coaxial cable
X	X		5173115-3	Run M1306, SPW-J120 to MAG-J12, A Transmit, 10218mm	1	25	0.6	15	6.0	152	1	N/A	CMR, FT4	4000	85°	LMR-600 coaxial cable
X	X		5173115-4	Run M1306, SPW-J120 to MAG-J12, A Transmit, 14305mm	1	25	0.6	15	6.0	152	1	N/A	CMR, FT4	4000	85°	LMR-600 coaxial cable
		X	5329340-7	Run M1305, SPW-J122 to PED-IO-J1, P1 port RF Transmit, 14306mm reference, Aluminum braid shield.	1	25	0.6	15	6.0	152	1	N/A	CMR, FT4	4000	85°	LMR-600 coaxial cable
		X	5329340-8	Run M1305, SPW-J122 to PED-IO-J1, P1 port RF Transmit, 18393mm reference, Aluminum braid shield.	1	25	0.6	15	6.0	152	1	N/A	CMR, FT4	4000	85°	LMR-600 coaxial cable

Illustration 6-12: System Cable List (Page 6)

450	750	450w	Part Number	Description	Connector Size/dia in	Connector Size/dia mm	Cable Diameter in	Cable Diameter mm	Bend Radius in	Bend Radius mm	Conductors	AWG	Certification	Volt Rating (volts)	Temp Rating (C)	Notes
		X	5329340-9	Run M1306, SPW-J120 to PED-IO-J2, A port RF Transmit, 13965mm reference, Aluminum braid shield.	1	25	0.6	15	6.0	152	1	N/A	CMR, FT4	4000	85°	LMR-600 coaxial cable
		X	5329340-10	Run M1306, SPW-J120 to PED-IO-J2, A port RF Transmit, 18052mm reference, Aluminum braid shield.	1	25	0.6	15	6.0	152	1	N/A	CMR, FT4	4000	85°	LMR-600 coaxial cable
		X	5329340-11	Run E1002 SPW-J128 to PGR-J18, RF Transmit, 10218mm, Aluminum braid shield.	1	25	0.6	15	6.0	152	1	N/A	CMR, FT4	4000	85°	LMR-600 coaxial cable
		X	5329340-12	Run E1002 SPW-J128 to PGR-J18,RF Transmit, 16348mm, Aluminum braid shield.	1	25	0.6	15	6.0	152	1	N/A	CMR, FT4	4000	85°	LMR-600 coaxial cable
X	X	X	5174110	Run E3025, CRY to MON-FJ4, Flow Monitor-Sumitomo, 10000mm	1.75	44	0.4	9	6.0	152	10	22	CMG, FT4	300	80°	
X	X	X	5344936	Run M2025 MAG to PEN, CAN fiber optic, 12500mm	2.4	61	0.8	21	7.0	178	8	N/A	LFNC	N/A	85°	optical fibers in conduit, 4 duplex connectors bundled
X	X	X	5344936-2	Run M2025 MAG to PEN, CAN fiber optic, 16500mm	2.4	61	0.8	21	7.0	178	8	N/A	LFNC	N/A	85°	optical fibers in conduit, 4 duplex connectors bundled
X	X	X	5184585	Run M3317 Gradient Cable X, Scan Room, Short,8700mm	2	51	2	51	###	330	5	4/C 2/0 AWG + 1/C 6 AWG	UL Type TC-ER, FT4	600	90°	
X	X	X	5184585-2	Run M3318 Gradient Cable Y, Scan Room, Short,8700mm	2	51	2	51	###	330	5	4/C 2/0 AWG + 1/C 6 AWG	UL Type TC-ER, FT4	600	90°	
X	X	X	5184585-3	Run M3319 Gradient Cable Z, Scan Room, Short,8700mm	2	51	2	51	###	330	5	4/C 2/0 AWG + 1/C 6 AWG	UL Type TC-ER, FT4	600	90°	
X	X	X	5184585-4	Run M3317 Gradient Cable X, Scan Room, Long,12700mm	2	51	2	51	###	330	5	4/C 2/0 AWG + 1/C 6 AWG	UL Type TC-ER, FT4	600	90°	
X	X	X	5184585-5	Run M3318 Gradient Cable Y, Scan Room, Long,12700mm	2	51	2	51	###	330	5	4/C 2/0 AWG + 1/C 6 AWG	UL Type TC-ER, FT4	600	90°	
X	X	X	5184585-6	Run M3319 Gradient Cable Z, Scan Room, Long,12700mm	2	51	2	51	###	330	5	4/C 2/0 AWG + 1/C 6 AWG	UL Type TC-ER, FT4	600	90°	
X	X	X	5184899	Run E3317 Gradient Cable X, Equip Room, Short,9400mm	2	51	2	51	###	330	5	4/C 2/0 AWG + 1/C 6 AWG	UL Type TC-ER, FT4	600	90°	
X	X	X	5184899-2	Run E3318 Gradient Cable Y, Equip Room, Short,9400mm	2	51	2	51	###	330	5	4/C 2/0 AWG + 1/C 6 AWG	UL Type TC-ER, FT4	600	90°	
X	X	X	5184899-3	Run E3319 Gradient Cable Z, Equip Room, Short,9400mm	2	51	2	51	###	330	5	4/C 2/0 AWG + 1/C 6 AWG	UL Type TC-ER, FT4	600	90°	
X	X	X	5184899-4	Run E3317 Gradient Cable X, Equip Room, Long,16400mm	2	51	2	51	###	330	5	4/C 2/0 AWG + 1/C 6 AWG	UL Type TC-ER, FT4	600	90°	
X	X	X	5184899-5	Run E3318 Gradient Cable Y, Equip Room, Long,16400mm	2	51	2	51	###	330	5	4/C 2/0 AWG + 1/C 6 AWG	UL Type TC-ER, FT4	600	90°	
X	X	X	5184899-6	Run E3319 Gradient Cable Z, Equip Room, Long,16400mm	2	51	2	51	###	330	5	4/C 2/0 AWG + 1/C 6 AWG	UL Type TC-ER, FT4	600	90°	
X	X		5189365	Run E1002 SPW-J128 to PGR-J18, RF Transmit, 10218mm	1.36	35	0.9	23	9.0	229	1	N/A	CMR, FT4	5000	85°	LMR-900 coaxial cable
X	X		5189365-2	Run E1002 SPW-J128 to PGR-J18,RF Transmit, 16348mm	1.36	35	0.9	23	9.0	229	1	N/A	CMR, FT4	5000	85°	LMR-900 coaxial cable
X	X	X	5191204	Run E2002 PGR-J1 to PEN-J19,10000mm	1.2	30	0.3	8	4.8	122	2	N/A	OFNR	N/A	85°	optical fibers, 2 simplex connectors bundled on each end

Illustration 6-13: System Cable List (Page 7)

					Connector Size/dia		Cable Diameter		Bend Radius							
450	750	450w	Part Number	Description	in	mm	in	mm	in	mm	Conductors	AWG	Certification	Volt Rating (volts)	Temp Rating (C)	Notes
X	X	X	5191204-2	Run E2002 PGR-J1 to PEN-J19,17000mm	1.2	30	0.3	8	4.8	122	2	N/A	OFNR	N/A	85°	optical fibers, 2 simplex connectors bundled on each end
X	X	X	5191204-3	Run E2023 PGR-J21 to PEN-J18,10000mm	1.2	30	0.3	8	4.8	122	2	N/A	OFNR	N/A	85°	optical fibers, 2 simplex connectors bundled on each end
X	X	X	5191204-4	Run E2023 PGR-J21 to PEN-J18,17000mm	1.2	30	0.3	8	4.8	122	2	N/A	OFNR	N/A	85°	optical fibers, 2 simplex connectors bundled on each end
X	X	X	5191301-2	Run P2003 PGR-J15 to Mag-J20,31000mm	1.2	30	0.4	10	5.7	145	6	N/A	OFNR	N/A	85°	optical fibers, 3 duplex connectors bundled on each end
X	X	X	5191301-3	Run P2004 PGR-J14 to Mag-J21,20000mm	1.2	30	0.4	10	5.7	145	6	N/A	OFNR	N/A	85°	optical fibers, 3 duplex connectors bundled on each end
X	X	X	5191301-4	Run P2004 PGR-J14 to Mag-J21,31000mm	1.2	30	0.4	10	5.7	145	6	N/A	OFNR	N/A	85°	optical fibers, 3 duplex connectors bundled on each end
X	X	X	5191924	Run E1003, PGR-J12 to PEN-J5, Body TR, 10000mm	0.63	16	0.2	6	2.5	64	1	N/A	CMR, FT4	1500	85°	LMR-240 coaxial cable
X	X	X	5191924-2	Run E1004 PGR-J13 to Pen-J6,Head TR,10000mm	0.63	16	0.2	6	2.5	64	1	N/A	CMR, FT4	1500	85°	LMR-240 coaxial cable
X	X	X	5191924-3	Run E1003 PGR-J12 to PEN-J5,Body TR,17000mm	0.63	16	0.2	6	2.5	64	1	N/A	CMR, FT4	1500	85°	LMR-240 coaxial cable
X	X	X	5191924-4	Run E1004, PGR-J13 to PEN-J6, Head TR,17000mm	0.63	16	0.2	6	2.5	64	1	N/A	CMR, FT4	1500	85°	LMR-240 coaxial cable
X	X	X	5192963	Run E2020 PGR-J22 to PEN-J17,10000mm	2.4	61	0.8	21	7.0	178	6	N/A	LFNC	N/A	85°	optical fibers in conduit, 3 connectors bundled on each end
X	X	X	5192963-2	Run E2020 PGR-J22 to PEN-J17,17000mm	2.4	61	0.8	21	7.0	178	6	N/A	LFNC	N/A	85°	optical fibers in conduit, 3 connectors bundled on each end
X	X	X	5194040	Run E3023 SPW-J117 to MON-J8,17000mm	2.5	64	0.4	11	6.0	152	25	22	CL3, FT4	300	80°	
X	X	X	5194540	Run P2026 OW to Mag-J11,Scan Room Display,40000mm	1.2	30	0.3	8	4.8	122	4	N/A	OFNR	N/A	85°	optical fibers, 2 duplex connectors bundled on each end
X	X	X	5194540-2	Run P2026 OW to Mag-J11,Scan Room Display,44000mm	1.2	30	0.3	8	4.8	122	4	N/A	OFNR	N/A	85°	optical fibers, 2 duplex connectors bundled on each end
X	X	X	5195200	Run E4005 RF COM GND STUD to PGR-GND STUD, 10000mm	0.81	20	0.6	15	7.0	178	1	1/0	UL AWM 1284, TEW	600	105°	single conductor ground cable
X	X	X	5195200-2	Run E4005 RF COM GND STUD to PGR-GND STUD, 17000mm	0.81	20	0.6	15	7.0	178	1	1/0	UL AWM 1284, TEW	600	105°	single conductor ground cable
X	X	X	5195200-3	Run M4005 RF COM GND STUD to MAG-GND STUD, 13500mm	0.81	20	0.6	15	7.0	178	1	1/0	UL AWM 1284, TEW	600	105°	single conductor ground cable
X	X	X	5195200-4	Run M4005 RF COM GND STUD to MAG-GND STUD, 17500mm	0.81	20	0.6	15	7.0	178	1	1/0	UL AWM 1284, TEW	600	105°	single conductor ground cable
X	X	X	5195200-5	Run E4009 RF COM GND STUD to SPW-GND STUD, 2800mm	0.81	20	0.6	15	7.0	178	1	1/0	UL AWM 1284, TEW	600	105°	single conductor ground cable
X	X	X	5195200-6	Run E4010 RF COM GND STUD to PEN-GND STUD, 2800mm	0.81	20	0.6	15	7.0	178	1	1/0	UL AWM 1284, TEW	600	105°	single conductor ground cable
X	X	X	5196045	Run E4002, PEN-GND to PGR-GND, Ground Cable, 10000mm	0.53	13	0.2	5	5.0	127	1	10	CMG	300	80°	single conductor ground cable
X	X	X	5196045-2	Run E4002, PEN-GND to PGR-GND, Ground Cable, 17000mm	0.53	13	0.2	5	5.0	127	1	10	CMG	300	80°	single conductor ground cable
X	X	X	5196045-4	Run E4007, HEC-GND to PGR-GND,Ground Cable, 10000mm	0.53	13	0.2	5	5.0	127	1	10	CMG	300	80°	single conductor ground cable

Illustration 6-14: System Cable List (Page 8)

					Connector Size/dia		Cable Diameter		Bend Radius							
450	750	450w	Part Number	Description	in	mm	in	mm	in	mm	Conductors	AWG	Certification	Volt Rating (volts)	Temp Rating (C)	Notes
X	X	X	5196045-5	Run E4008, OW-GOC-GND to PGR-GND, Ground Cable, 30000mm	0.53	13	0.2	5	5.0	127	1	10	CMG	300	80°	single conductor ground cable
X	X	X	5197321-2	Run M3023 SPW-J117 to Mag-FJ2,14000mm	2.5	64	0.4	11	6.0	152	25	22	CL3, FT4	300	80°	

450	750	450w	Part Number	Description	OD in.	OD mm
X	X	X	5199506-2, -3, 46-282666P15, 16, 17,	4" ID Air Hose	4.5	113.8
X	X	X	5213158	3" ID Air Hose	3.4	86.3
		x	46-282666P18	1.5" ID Air Hose	1.8	44.9
X	X	X	5264083, 5264066, 5264105, 5264042	1" Coolant Hose	1.3	32.6
X	X	X	5264063, 5264039	1/2" Coolant Hose	0.8	19.8
X	X	X	5225963	4" Hose Insulation	5.5	139.2
X	X	X	5305915	3" Hose Insulation	4.4	111.7
X	X	X	5225968	1" Hose Insulation	2.3	58.0
X	X	X	5197470	1/2" Hose Insulation	2.3	57.9
X	X	X	2154502-2	20 meter Helium hose (Supply)		
X	X	X	2154505-2	20 meter Helium hose (Return)		
X	X	X	2250629	6 meter Helium hose extension		
X	X	X	2250631	7 meter Helium hose extension		

4 Facility Supplied System Interconnects Specifications

The following table lists the required facility supplied system interconnects. Refer to Illustration 6-15 for additional information.

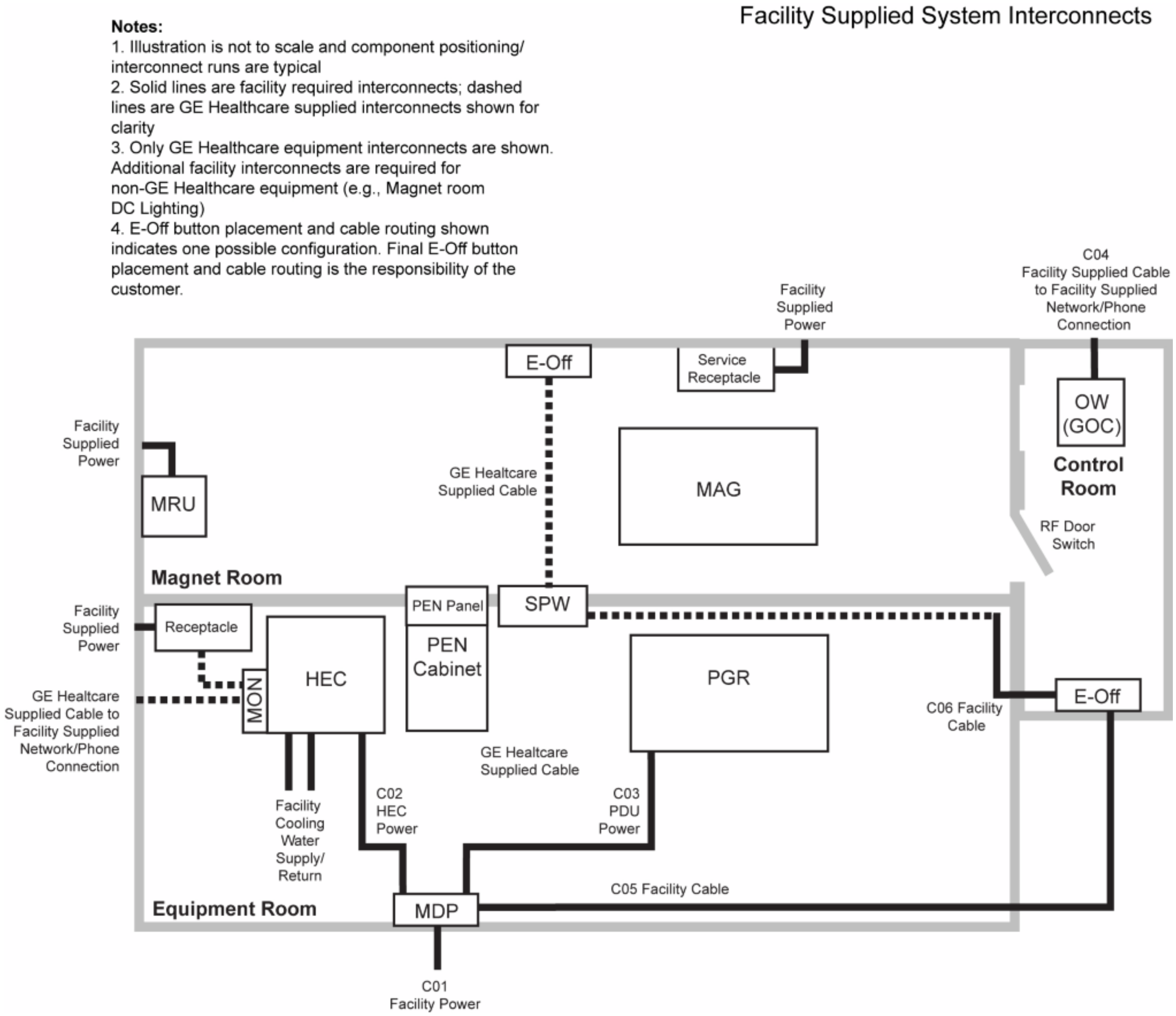
Table 6-6: Facility Supplied System Interconnects

Group	Between Units		Comments	Requirements
	From	To		
C01	Facility Power	MDP	Facility Power and Ground	Chapter 2, MR Suite Electrical Requirements
C02	MDP	HEC	HEC Power	
C03	MDP	PGR	PDU Power	
	Facility Cooling Water	HEC	Cooling Water Supply	Chapter 2, MR System Facility Water Requirements
	Facility Cooling Water	HEC	Cooling Water Return	
C04	Facility Network	MON	Facility must provide network/telephone access for the Magnet Monitor (MON) and Global Operator Cabinet (GOC). The MON connection must be available at all times.	Chapter 4, Magnet Monitor (MON) Requirements and Specifications
	Facility Network	GOC		
C05	MDP	E-Off Switch	Facility must supply cable from MDP to E-Off Switch in Equipment Room	Chapter 2, MR Suite Electrical Requirements
	Facility Power	Outlet near MON	Facility outlet for MON power	Chapter 4, Magnet Monitor (MON) Requirements and Specifications
	Facility Power	MRU	Facility power to MRU	Chapter 3, Magnet Room Equipment Specifications
C06	GE Healthcare Supplied Cable from SPW	E-Off Switch in Control room or Equipment room	Facility must supply additional wiring between the GE Healthcare supplied cable and the E-Off switch if the length needed is greater than the usable length listed in MR System Interconnects Specifications	Chapter 2, MR Suite Electrical Requirements

Table 6-7: Optional Facility Supplied System Interconnects

Group	Between Units		Comments	Requirements
	Facility Power	Outlet near MRE	Facility outlet for MRE power (optional, not shown)	Chapter 4, Magnetic Resonance Elastography (MRE) Specifications

Illustration 6-15: Facility Supplied System Interconnects



NOTE: GE Healthcare recommends installing the RF Door switch on the outside wall of the Magnet room.

Chapter 7 Appendicies

1 Glossary

BB
Abbreviation for Broadband

Cryogen

A substance for producing low temperatures. Liquid helium is the cryogen used to cool the magnet to approximately 4 Kelvin (-269°C or -452°F).

Cryostat

An apparatus maintaining a very low constant temperature. The cryostat consists of one concentric, cylindrical container housed in an outer vacuum tight vessel. The magnet and shim coils are mounted in the inner container. The container is filled with liquid helium. The shields surrounding the inner container are kept cold by a refrigeration device.

Dewar

A container with an evacuated space between two highly reflective walls used to keep low temperature substances at near-constant temperatures. Liquid helium is usually stored and shipped in dewars.

Exclusion Zone

Area where the magnetic flux density is greater than five gauss. Personnel with cardiac pacemakers, neurostimulators and other biostimulation devices must NOT enter this zone. Signs are posted outside the five gauss line alerting personnel of this requirement. Since the magnetic field is three-dimensional, signs are also posted on floors above and below the Magnet Room in which the five gauss line exists.

Ferrous Material

Any substance containing iron which is strongly attracted by a magnetic field.

Gauss (G)

A unit of magnetic flux density. The earth's magnetic field strength is approximately one half gauss to one gauss depending on location. The internationally accepted unit is the tesla (1 Tesla = 10,000G and 1 milli Tesla = 10G).

Gradient

The amount and direction of the rate of change in space of the magnetic field strength. In the magnetic resonance system, gradient amplifiers and coils are used to vary the magnetic field strength in the x, y, and z planes.

Homogeneity

Uniformity. The homogeneity of the static magnetic field is an important quality of the magnet.

Isocenter

Center of the imaging volume ideally located at the magnet center.

Isogauss Line

An imaginary line or a line on a field plot connecting identical magnetic field strength points.

Magnetic Field (B)

A condition in a region of space established by the presence of a magnet and characterized by the presence of a detectable magnetic force at every point in the region. A magnetic field exists in the space around a magnet (or current carrying conductor) and can produce a magnetizing force on a body within it.

Magnetic Resonance (MR)

The absorption or emission of electromagnetic energy by nuclei in a static magnetic field, after excitation by a suitable radio frequency field.

Magnetic Sheilding

Using material (e.g. steel) to redistribute a magnetic field , usually to reduce fringe fields.

NB

Abbreviation for Narrow Band

Quench

Condition when a superconducting magnet becomes resistive thus rapidly boiling off liquid helium. The magnetic field reduces rapidly after a quench.

Radio Frequency (RF)

Frequency intermediate between audio frequency and infrared frequencies. Used in magnetic resonance systems to excite nuclei to resonance. Typical frequency range for magnetic resonance systems is 5-130 Mhz.

Radio Frequency Shielding

Using material (e.g. copper, aluminium, or steel) to reduce interference from external radio frequencies. A radio frequency shielded room usually encloses the entire magnet room.

Resonance

A large amplitude vibration caused by a relative small periodic stimulus of the same or nearly the same period as the natural vibration period of the system. In magnetic resonance imaging, the

radio frequency pulses are the periodic stimuli which are at the same vibration period as the hydrogen nuclei being imaged.

Security Zone

Area within the Magnet Room where the magnet is located. Signs are posted outside the Magnet Room warning personnel of the high magnetic field existing in the Magnet Room and the possibility of ferrous objects becoming dangerous projectiles within this zone.

Shield Cooler Coldhead

An external refrigeration device which maintains the shields inside the cryostat at a constant temperature.

Shim Coils

Shim coils are used to provide auxiliary magnetic fields in order to compensate for inhomogeneities in the main magnetic field due to imperfections in the manufacturing of the magnet or affects of steel in the surrounding environment.

Shimming

Correction of inhomogeneity of the main magnetic field due to imperfections in the magnet or to the presence of external ferromagnetic objects.

Superconducting Magnet

A magnet whose magnetic field originates from current flowing through a superconductor. Such a magnet is enclosed in a cryostat.

Superconductor

A substance whose electrical resistance essentially disappears at temperatures near zero Kelvin. A commonly used superconductor in magnetic resonance imaging system magnets is niobium-titanium embedded in a copper matrix.

Tesla

The internationally accepted unit of magnetic flux density. One tesla is equal to 10,000 gauss. One milli Tesla is equal to 10 gauss.

2 MR Site Vibration Test Guidelines

2.1 Test Measurements

1. Vibration measurements must be in the range of 10^{-6} g. Test equipment must have the required sensitivity to these levels
2. Instrumentation must have a low tolerance to temperature effects since many times the low frequency thermal drift may influence the measurements
3. All measured data must be acquired real time. Recording of vibration data will not allow for a proper site survey, specifically when studying transient vibration and when searching for specific vibration sources
4. All analyses must be narrow-band Fast Fourier Transforms (FFT) over the frequency bands listed in Table 7-1
5. Time histories of the vibration must be recorded as acceleration levels vs. time. The resolution of the time history must be adjusted to clearly capture the transient event. The analyzer set-up will be site dependent and, in special cases, vibration response dependent. It is the responsibility of the vibration consultant to study the transient environment, capture data to confirm that transient activity exceeds the trigger level, then expand the time history data to exhibit the structural response

Table 7-1: Frequency Bands for FFT

Frequency Band	Frequency Resolution
0.2 to 50 Hz	$\Delta f = 0.125$ Hz

2.2 Equipment (Spectral Analyzer) Set-Up

1. Frequency average should be a minimum of 20 linear averages (Do not use peak hold or 1/3 octave analysis)
2. Average and store should be a minimum of 20 plots steady state and 20 plots transient to support the consistency of the site vibrations
3. Hanning windows must be applied to the entire spectra
4. Spectrum analyzers capable of these measurements are readily available for purchase or rental. Models, such as the HP 3560A, Nicolet Phaszer, B&K Pulse, and HP 35670, are all capable of making the site vibration measurements. Accelerometers must have the capability to measure from 0.2 Hz beyond 50 Hz. Time histories can be recorded using any of the analyzers listed above

   NOTE: The equipment mentioned is for example only. It is the responsibility of the Engineering Test Firm to provide equipment that will allow measurements compliant with this guideline.

2.3 Data Collection

2.3.1 Ambient Baseline Condition

1. All of the measurements listed above must be made in a “quiet” environment--i.e., areas where excessive traffic, subway trains, etc. do not exist. A vibration measurement must also be made during periods without traffic or during periods of light traffic. Measurements must define the lowest levels of vibration possible at the site
2. The source of any steady state vibration, whose level exceeds the magnet specifications found in Chapter 3, Magnet Room Structural Requirements, must be identified. A second measurement should be made with all of the identified contributors powered down if possible. In situations where it is not possible to power down equipment, vibration data must be collected to identify the specific source of the vibration concern. The majority of steady state vibration problems can be negated by isolating the vibration source

2.3.2 Normal Condition

1. All of the vibration measurements listed above must be repeated during periods of “normal” environmental conditions, including the FFTs and time histories. The transient measurements must be provided to define the dynamic disturbances the MR system may be exposed to. Transient analysis is required for a true assessment of the site
2. Special attention must be paid to the site assessment during the entire analysis. Since transient vibration is not easily addressed once the MR suite is fully constructed, the test consultant must fully understand the needs for this analysis. The source of any transient vibration must be identified and supported with vibration plots. If the source of any transient vibration is not locatable, it is recommended that the customer have an alternate location identified and the vibration studied
3. Transient vibration can be difficult to assess if the details are not understood. The **0.0005g, zero-to-peak trigger level** is a starting point to understanding the vibration stability. The transient vibration peak amplitude, structural (time variant) response, decay rate and an estimate of the number of events per unit of time would constitute a complete transient analysis. All transient failures must be supported by time history plots. The plots must clearly show the structural response, the frequency of the signature and the decay rate. From this data, GE Heatlhcare can help determine compliance with the vibration guidelines
4. The test consultant must provide site data to show the design recommendations for all sites/ building structures meet the Magnet specifications found in Chapter 3, Magnet Room Structural Requirements

2.4 Presentation/Interpretation of Results

1. The recommended format for site vibration data collection, presentation, and analysis is demonstrated in the examples in Illustration 7-1, Illustration 7-2, Illustration 7-3, and Illustration 7-4. Presentation of the data in any other format (linear units only) may result in incorrect interpretation and diagnosis of the site. Additional data collection or presentation methods are at the option of the vibration testing service
2. All plots must be properly annotated with:
    a. Instrumentation setup including number of averages, frequency resolution, etc.

   b. Test location
   c. Test conditions:
      i. Steady state
      ii. Transient
      iii. Heel drop
      iv. Normal environment
      v. Typical traffic
      vi. Any other conditions necessary to demonstrate understanding of potential sources of vibration
3. The customer's vibration testing service is responsible for interpreting the results and determine if that site meets GE Healthcare specifications
4. If the vibration levels are too high, additional data acquisition may be necessary to:
   a. Determine the source of the vibration
   b. Propose a solution to the problem
   c. Find an alternate site location
5. Any questions regarding test equipment requirements, test parameters, or general questions should be discussed with the GE Healthcare Project Manager of Installation (PMI)

Illustration 7-1: Example of Site Environmental Vibration Levels

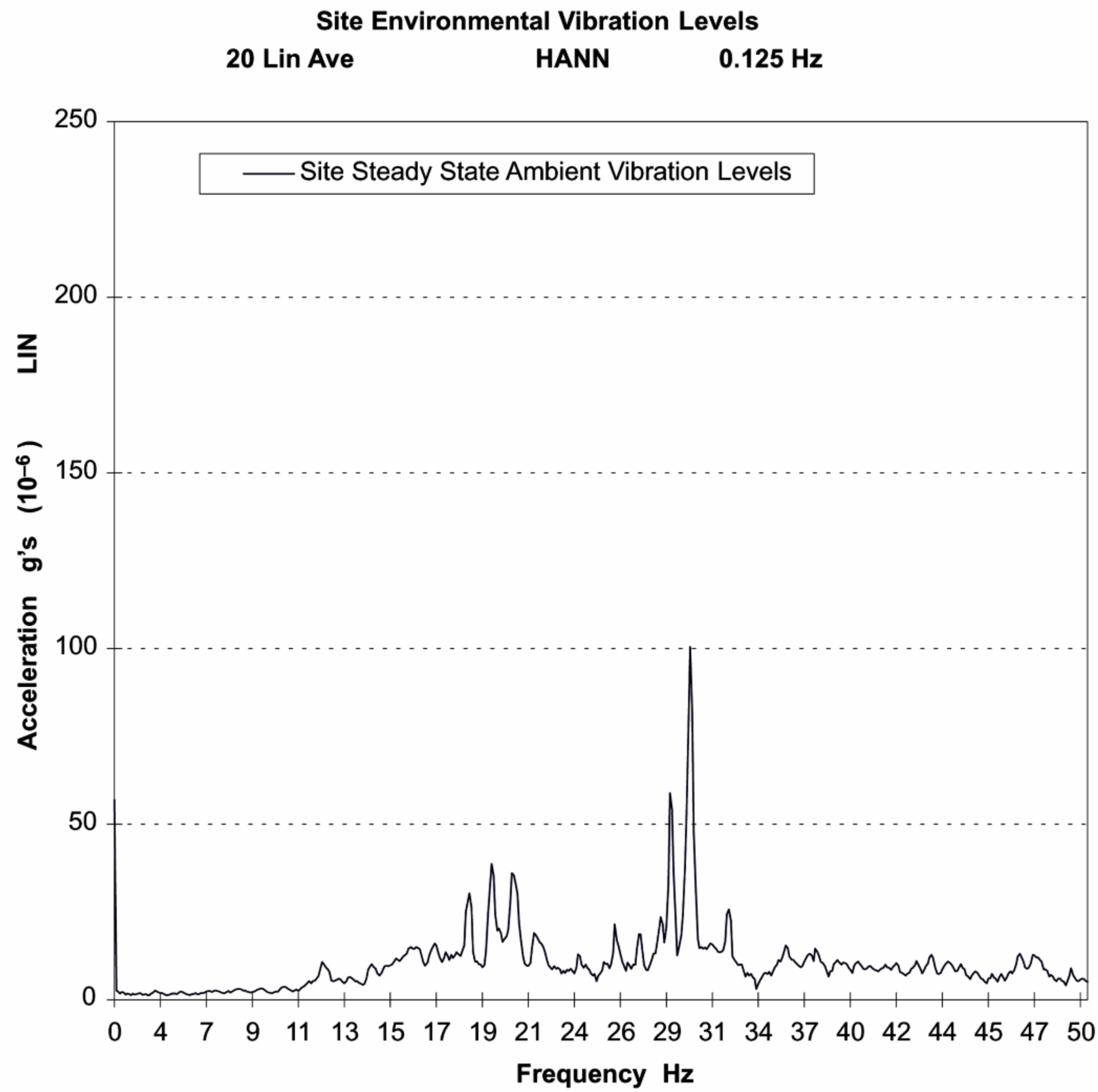


Illustration 7-2: Example Site Environmental Vibration

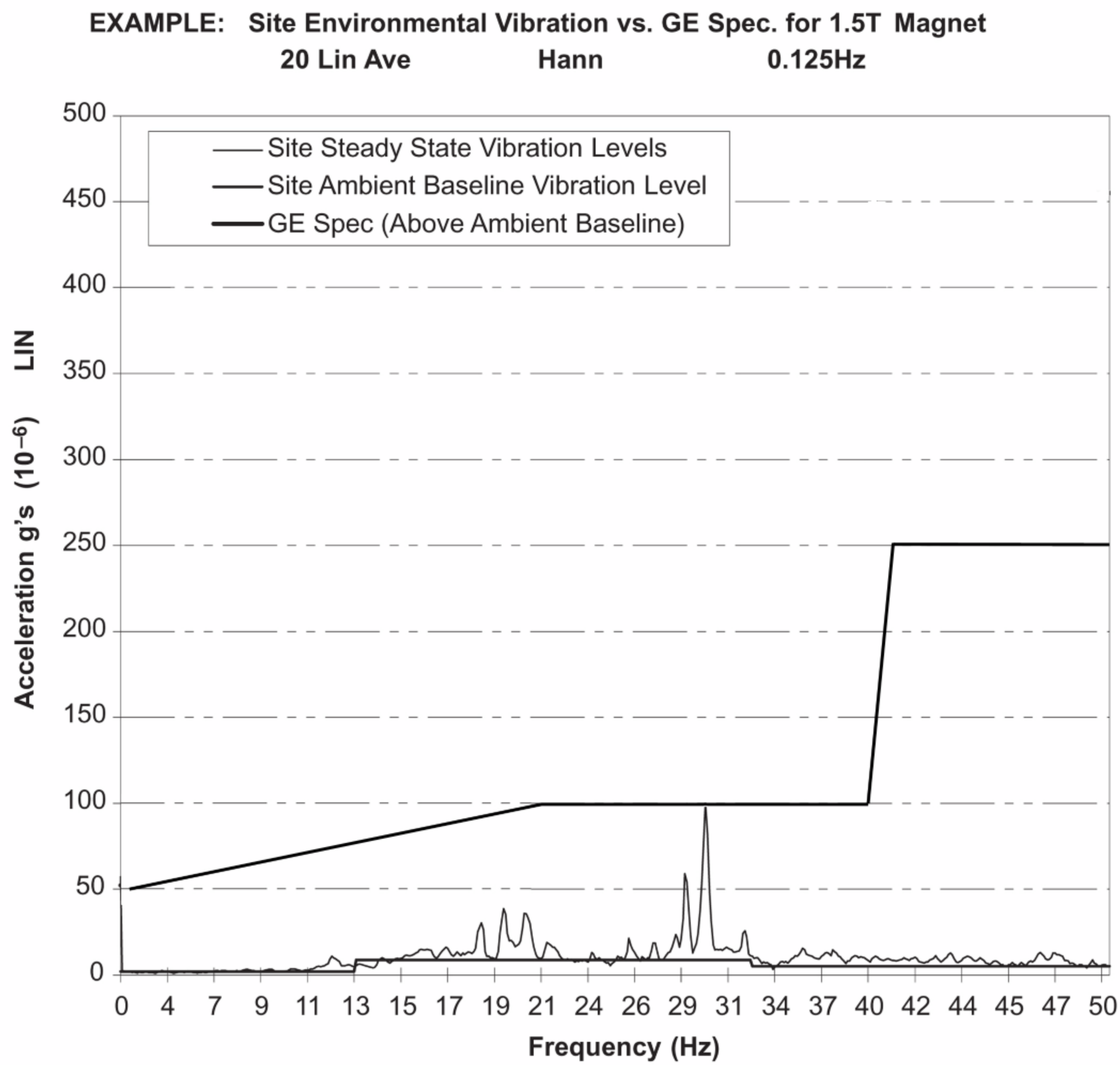


Illustration 7-3: Acceleration Time History

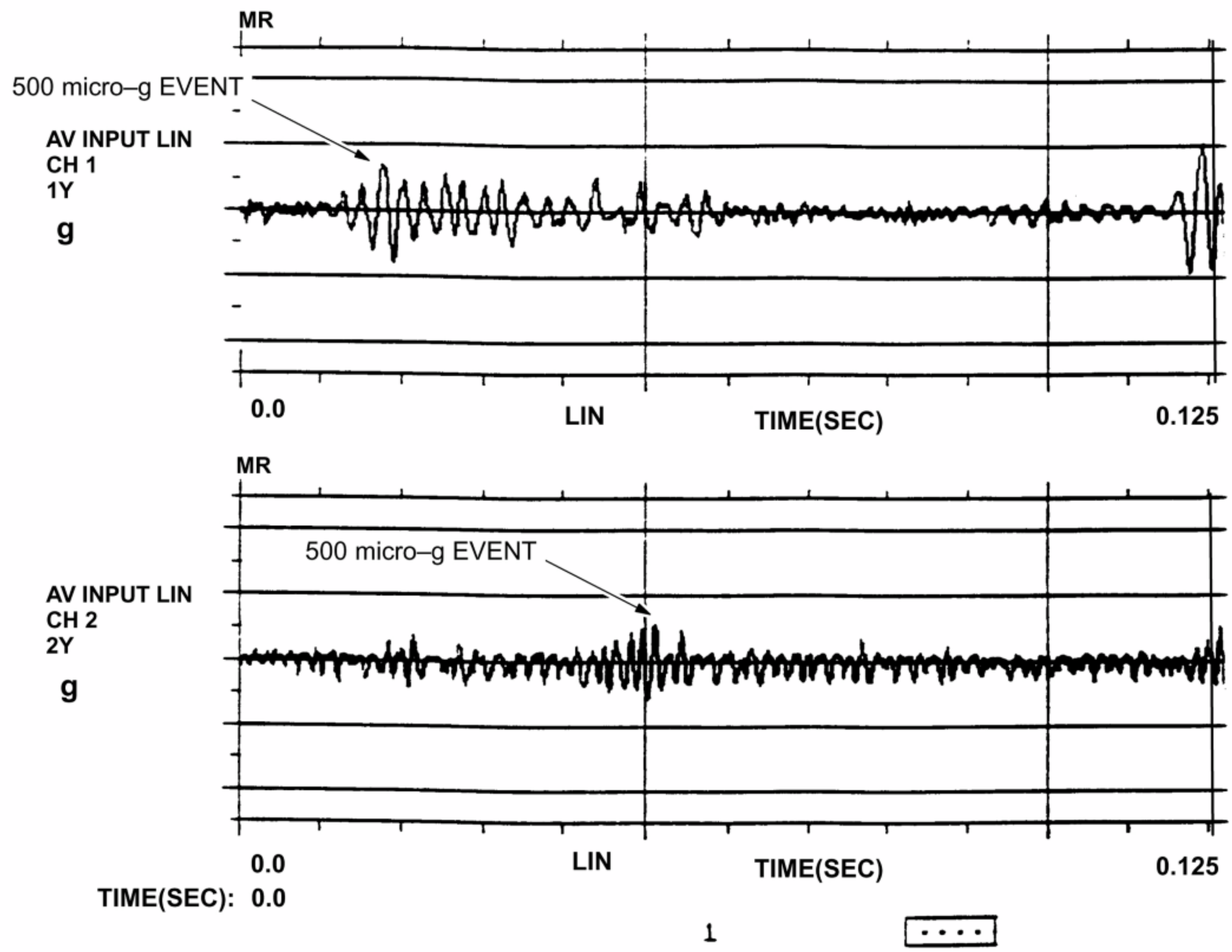
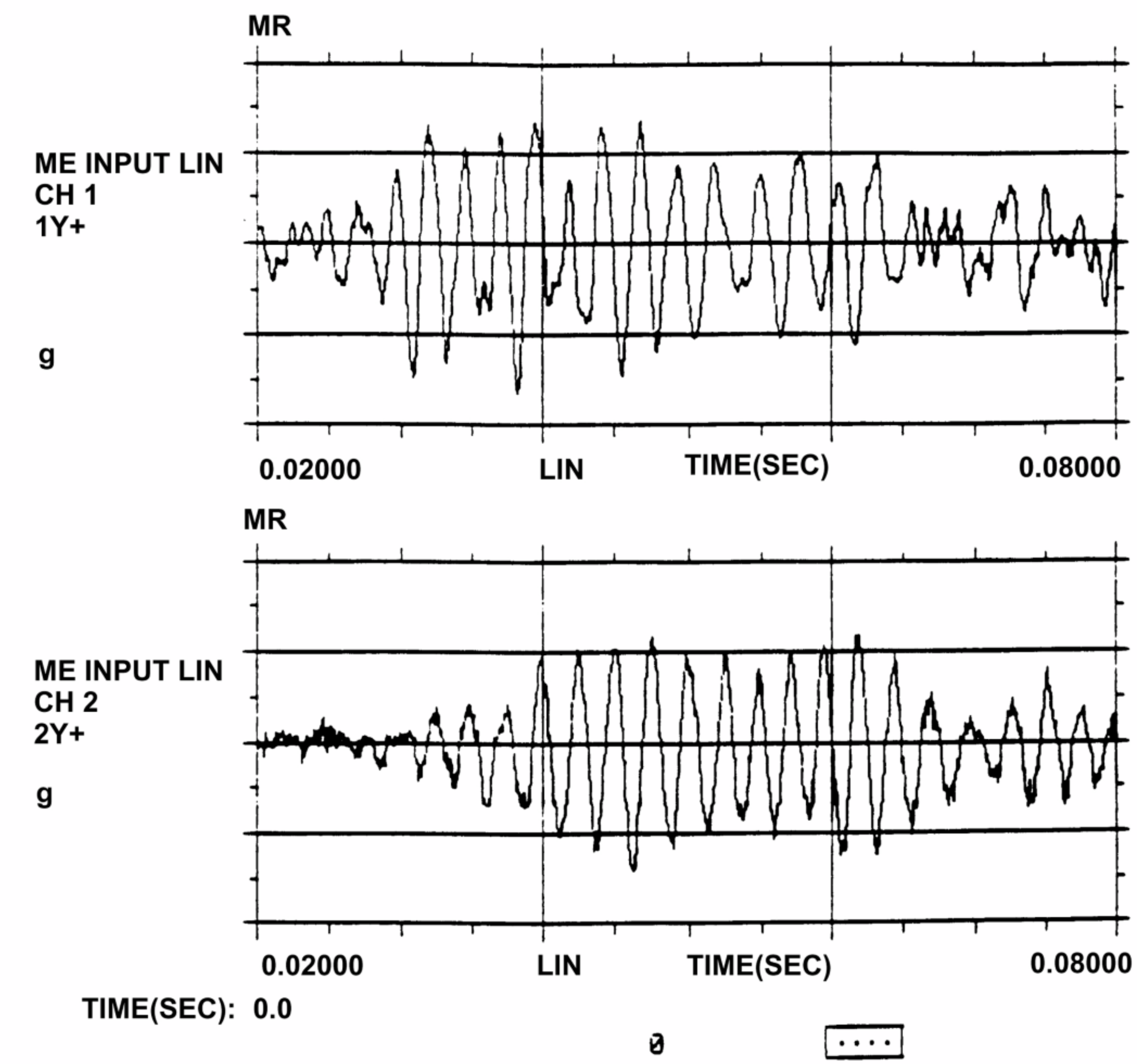


Illustration 7-4: Acceleration Time History (Zoomed In on Transient Event)



3 RF Shielding Guidelines

RF sources which can adversely affect image quality may be generated by discrete frequency or broadband noise (RF) sources.

3.1 Discrete RF Interference

Discrete RF interferences are narrowband and are fixed frequency in nature. The Magnet Room must be RF shielded from RFI sources so external RF energy does not degrade the MR system RF receivers at the system imaging frequencies. Some potential sources for discrete frequency signals are radio station transmitters, mobile or hand-held RF transmitting devices, in general any intended RF transmitter or non-intended transmitters but with clocked digital electronic circuits.

3.2 Broadband RF Interference

Broadband RF noise is a single transient or continuous series of transient disturbances caused by an electrical discharge. Low humidity environmental conditions will have higher probability of electrical discharge. The electrical discharge can occur due to electrical arcing (micro arcing) or merely a static discharge. Some potential sources capable of producing electrical discharge include:

1. Loose hardware/fasteners vibration or movement (electrical continuity must always be maintained)
2. Flooring material including raised access flooring (panels & support hardware) and carpeting
3. Electrical fixtures, including:
    a. Lighting fixtures
    b. Track lighting
    c. Emergency lighting
    d. Battery chargers
    e. Outlets
4. Ducting for HVAC and cable routing
5. RF Shield seals (walls, doors, windows, etc.)

4 RF Shielded Enclosure Test Guidelines

4.1 Introduction

This document describes guidelines for performing an RF shielding Effectiveness (SE) verification test on the RF Shielded Room that will house GE Healthcare Magnetic Resonance Imaging (MRI) equipment. MRI equipment is sensitive to RF energy from sources outside of the RF shielded room. To ensure proper operation of the MRI equipment, the RF shielded room must attenuate local RF electromagnetic energy to levels that do not cause interference.

NOTE: RF Shielding Performance is based on plane-wave measurements. *H* and *E* field tests are not required, but are allowed as needed for diagnostic purposes.

4.2 Purpose of Test Guideline

The purpose of this test guideline is to describe the recommended test procedure for RF shielding effectiveness (SE) to demonstrate the MRI RF shielded room is in compliance with GE Healthcare requirements.

The test guideline is based on IEEE Std 299-2006. This guideline provides a thorough evaluation of the RF shielding integrity at the frequency(ies) of interest of interest showing any RF leakage that may cause a degradation to the MR System performance for the image quality (i.e., induced image artifacts). These testing guidelines ensure that the electromagnetic environment inside of the enclosure will meet the requirements of GE Healthcare.

4.3 Reference Document

IEEE Std 299-2006 - IEEE STANDARD METHOD FOR MEASURING THE EFFECTIVENESS OF ELECTROMAGNETIC SHIELDING ENCLOSURES; 29 December 2006.

4.4 Test Set-Up for RF Shielded Room

The shielded enclosure under testing will be set up in a normal configuration that consists of:

1. Magnet installed including all floor mounting bolts (including dock anchor bolt)
2. RF shielded door(s)
3. Waveguide penetrations, HVAC, vents, medical gas lines, etc.
4. AC power supplied through low-pass filters
5. Patient view window, skylights, windows, hatches, etc.
6. Blank penetration panel installed, dimensionally equivalent to the GE panel and the same mounting hardware to be used with the GE penetration panel

NOTE: A GE Field Engineer is responsible for disconnecting cryocooler lines.

For safety reasons, the enclosure will be electrically grounded during the shielding effectiveness test. Any variances from the normal configuration will be noted in the certification report.

4.5 Shielding Effectiveness (SE)

This test procedure determines the worst case shielding effectiveness based on the lowest test point reading obtained. The lowest reading obtained will be the reading to indicate the SE performance of the RF shielded room.

4.6 Reference Level and Dynamic Range

1. The reference level is the value of signal measured by the receiver equipment with the receiving antenna located at a prescribed distance from the transmit antenna and located outside of the shielded enclosure.
2. The dynamic range (DR) is the range of amplitudes over which the receive system operates linearly. The dynamic range shall be at least 6dB greater than the SE to be measured. For SE measurement, the dynamic range is the difference of the reference level to the noise floor.

4.7 Test Equipment

1. Test equipment shall be selected to provide measuring capabilities as described in this test guideline
2. The equipment used for the SE measurement shall be in calibration before any measurement is begun. Dates of latest calibration shall be provided and shall be within the calibration cycle of the equipment. Equipment calibration is required to be traceable to the National Institute of Standards and Technology (NIST)
3. All equipment will be verified for proper operation between and after each series of tests by repeating the reference readings at the specified frequency.
4. Required equipment for transmit chain of measurement system:
    a. Frequency Synthesizer or Signal Generator.
    b. RF Power Amplifier (if required)
    c. DC Power Supply (if required)
    d. Tuned λ/2 Dipole antenna @ 100 MHz
5. Required equipment for receive chain of measurement system
    a. Spectrum analyzer
    b. RF preamplifier (if required)
    c. In-line attenuator (if required)
    d. DC power supply (if required)
    e. Tuned λ/2 Dipole antenna @ 100 MHz
6. The transmit and receive antenna must be of the same type for each measurement

4.8 Test Frequency

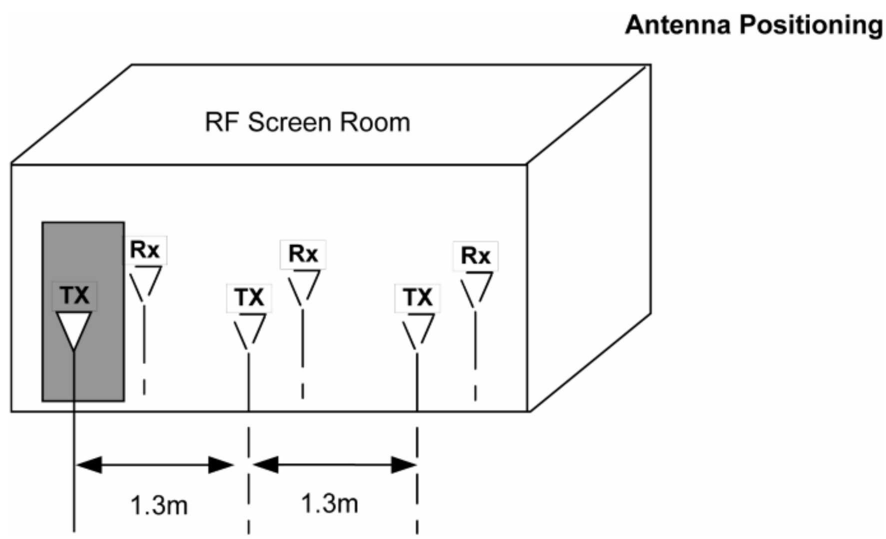
The standard frequency for shielding effectiveness (SE) measurement will be 100 MHz ±1 MHz. This allows the frequency to be adjusted slightly to avoid interference from local active transmitters and/or RF noise from other sources. Test frequency used will be noted in the test report.

4.9 Measurement Procedure

NOTE: Except when specified, antenna distances are measured at the center of the antenna.

1. Each wall of the RF shielded room that is accessible for the measurement will be tested. For areas that are inaccessible for the direct location of the transmitting antenna, the inside of that area will still be scanned using the receiving antenna with the transmitting antenna positioned as close as possible to the intended test position, that position shall be noted on the test report
2. Each accessible plane of the wall is subdivided so that the horizontal spacing is no more than 1.3 m (4 ft 3 in.) for the Transmit Antenna (TX) and Receive Antenna (RX) horizontal positions. See the illustration below:

Illustration 7-5: Antenna Positioning



3. Measurements are taken with horizontal and vertical antenna polarizations. Both Transmit (TX) and Receive (RX) antennas must be aligned with the same polarization, the measured polarization shall be part of the test report
4. For localized testing of screen room items such as doors, windows, filters, penetration areas, etc. the transmitting antenna (as well as receiving antenna) will be positioned in front of the items under test

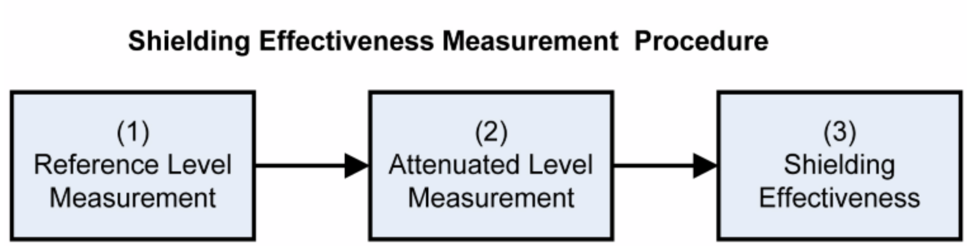
4.9.1 Shielding Effectiveness Measurement

Three main steps are required to complete the Shielding Effectiveness measurement at each test position:

1. Take reference level measurement,
2. Take attenuated level measurement

3. Calculate Shielding Effectiveness as shown below:

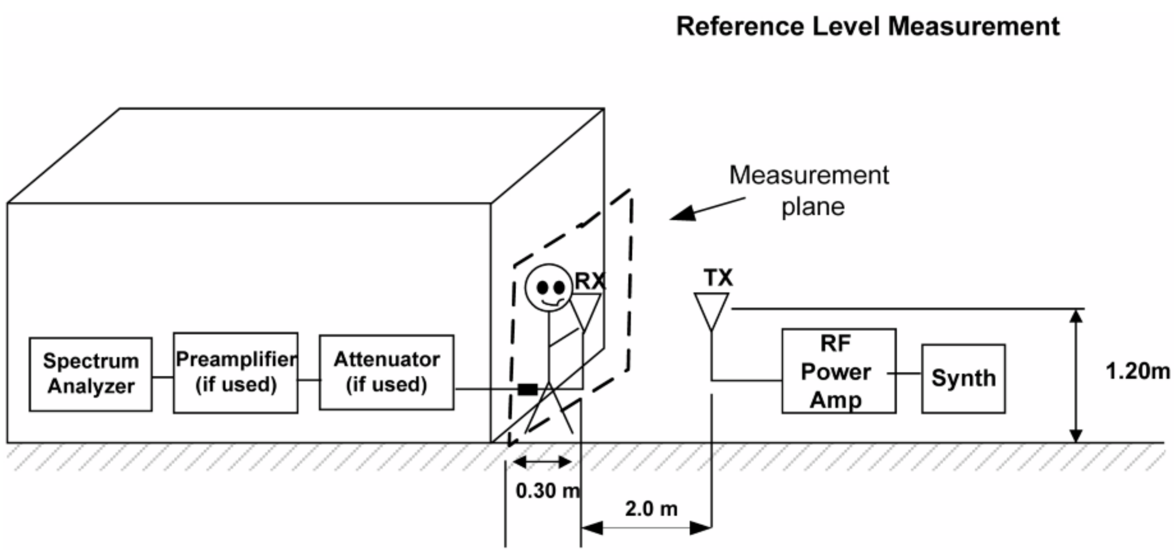
Illustration 7-6: Shielding Effectiveness Measurement Procedure



4.9.2 Reference Level Measurement

1. The reference level is the value of signal measured by the receiver equipment with the receiving antenna located at a prescribed distance from the transmit antenna and located outside of the shielded enclosure.
2. Measurement setup for the reference level is in accordance with the illustration below:

Illustration 7-7: Reference Level Measurement



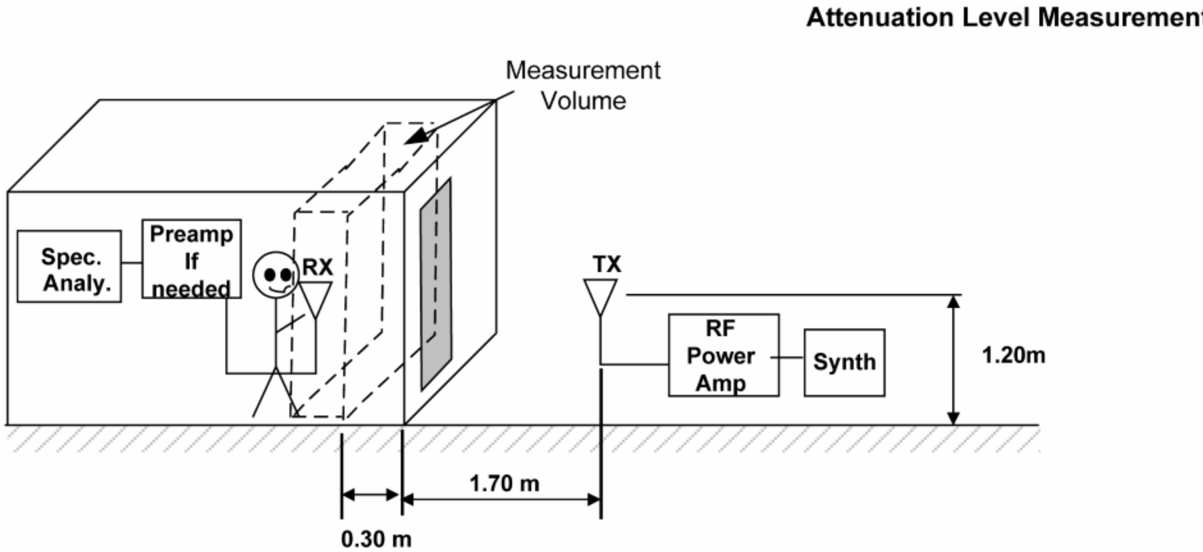
3. The antennas shall be separated by a distance of 2 m, minimum, unless physical spacing limitations for either the reference level or SE readings preclude maintaining that spacing. In that event, maximum available separation shall be used, but shall not be less than 1 m, and that separation shall be noted on the test report
4. The coaxial cable from the receive antenna shall be kept perpendicular to the axis of the antenna for a distance of at least 1 m
5. The cable from the receive antenna is preferably routed through the wall of the shield via a bulkhead type of coaxial connector. If this is not possible, it may be routed through a shield door that is opened only far enough to pass the cable. If the open-door method is used, a check for direct coupling to the receiving equipment shall be made by putting a dummy load in place of the receive antenna and verifying that any signal present is at least 10 dB below the reference reading

6. Reference Level measurement is taken at each test location with antenna at both polarizations (horizontal and vertical)
    a. Reference Level at Horizontal Polarization
        i. The reference level measurement is taken over a plane area covered as described below.
        ii. With horizontal polarization for both antennas, the receive antenna shall be moved vertically up 1.0 m from the initial position, and then move it down from the initial position to 0.3 m above the floor. Then starting 1 m to the right of the initial position, move slowly vertically up 1 m and then down to 0.3 m above the floor. Repeat this at 1 m to the left of the original position
        iii. Record the maximum measurement reading in this plane
    b. Reference Level at Vertical Polarization
        i. The reference level measurement is taken over a plane area covered as described below.
        ii. With vertical polarization for both antennas, the receive antenna shall be moved horizontally right 1.0 m from the initial position, and then move it left from the initial position to 1.0 m. Then starting 1 m above the initial position, move slowly horizontally right 1 m and then horizontally left 1 m from initial position. Repeat this at 0.3 m above the floor (measure 0.3 m from the floor to the bottom of the antenna), move slowly horizontally right 1 m and then horizontally left 1 m
        iii. Record the maximum measurement reading in this plane

4.9.3 Attenuated Level Measurement

1. The basic measurement procedure consists of positioning the transmit antenna outside the RF shielded room and the receive antenna inside the RF shielded room and measuring the magnitude of the largest received signal
2. The Transmit Power for the Screen Room Measurement is the same as the power used to determine the Reference Level
3. If an attenuator was used in the Reference measurement, it would be taken out for the Screen Room measurement and the attenuator value added to the SE in the datasheet
4. Measurement setup for the attenuated level is in accordance with the illustration below:

Illustration 7-8: Attenuation Level Measurement



5. Attenuated Level measurement is taken at each test location with antenna at both polarizations (horizontal and vertical).
   a. Attenuated Level at Horizontal Polarization
      i. Both tuned Receive and Transmit Antennas are in Horizontal Polarization
      ii. In all the following measurements the Receive Antenna is held in Horizontal Polarization and kept at a distance of 0.3 m from the inside screen room wall
      iii. Starting with the Receive Antenna directly parallel to the Transmit Antenna begin to slowly move the Receive Antenna in a Volume Parallel to the screen room wall 1 m above initial position and 0.3 m above the floor and 1m to the left and right of the initial position, see figure x
      iv. Measure and record the highest power in this volume
   b. Attenuated Level at Vertical Polarization
      i. Both tuned Receive and Transmit Antennas are in Vertical Polarization
      ii. In all the following measurements the Receive Antenna is held in Vertical Polarization and kept at a distance of 0.3 m from the wall
      iii. Starting with the Receive Antenna directly parallel to the Transmit Antenna begin to slowly move the Receive Antenna in a Volume Parallel to the screen room wall 1 m above the initial position and 0.3 m above the floor (measure 0.3 m from the floor to the bottom of the antenna) and 1 m to the left and right of the initial position
      iv. Measure and record the highest power in this volume

4.9.4 Shielding Effectiveness calculation

The shielding effectiveness is calculated with the reference level measurement and the attenuated level measurement as defined in Equation 1:

$$SE\ (db) = V_{Ref_max} - V_{Att_max}$$

or

$$SE\ (db) = P_{Ref_max} - P_{Att_max}$$

Where:

SE : Shielding Effectiveness in dB

V_{Ref_max}, V_{Att_max}: Reference measurement in dBuV

P_{Ref_max}, P_{Att_max}: Reference measurement in dBm

4.10 RF Screen Room Ground Isolation Resistance Measurement Guideline

1. This section does not apply to upgrades
2. This test must be made using either an isolated, current limited, high-voltage (>150 VDC) DC source and DMM to read drop across the limiting resistor or a Megger instrument capable of reading values less than 1000 ohms. Conventional resistance meters employing test sources of 9 VDC or less must not be used
3. To prevent personal hazard, it is necessary for the enclosure to be properly grounded
4. The ground isolation resistance measurement is performed by the following procedure:
    a. All power to the enclosure is removed. For safety reasons, an AC voltage measurement will be made to verify that no power is connected
    b. With electrical power and intentional ground disconnected, connect the test instrument between the shielded enclosure and AC power ground
    c. Take a reading and record the value

4.11 Data Recording (Test Report)

A final test report must be generated for the Shielding Effectiveness test. This test report will include all recorded data necessary for the evaluation of the RF shielded room.

1. GE Healthcare requires the test report include as a minimum the following information:
    a. Name of the owner organization or hospital
    b. Name of testing organization
    c. Identification name for the RF screen room being tested
    d. Name of test personnel
    e. Date of test
    f. Frequency(ies) tested
    g. SE measured for each test point location (each test point location must be identified in the test report)

h. List any changes pertinent to the test set-up or SE

i. Pass/Fail conclusion

2. Recommended additional information:

   a. RF screen room drawing showing each test point location

   b. Location of RF shielded room relative to the whole building where it is installed

   c. Identification of calibrated equipment used for measurement:

      i. Manufacturer

      ii. Model

      iii. Serial number

      iv. Calibration due date

   d. Pictures or RF screen room shielding effectiveness test showing:

      i. Overall view of RF shielded room

      ii. Window(s), door(s), filter(s)

      iii. Blank penetration panel · Installed additional penetration points (waveguides, vents, ducts, etc.)

      iv. Test set-up for reference level measurement

      v. Test set-up for attenuated level measurement

5 Acoustic Background and Design Guidelines

The acoustic information is provided for site planning and architectural design activities to address acoustics to meet local regulations and customer requirements. For more information about recommended safety procedures regarding patient exposure to MR generated acoustic levels, see the MR Safety Guide included with the system Users Manual.

5.1 Acoustic Background

A typical MR suite has two types of acoustic noise issues. The first is the acoustics within the rooms in which the patients and technicians are impacted by the noise of the MR system as the gradients are pulsed. The second is noise transmitted to other spaces via airborne and structureborne paths.

5.1.1 Airborne

The airborne transmission path entails the excitation of air within the magnet room; the resonator module consisting of the magnet, RF coil, and gradient coil generates acoustic noise similar to an intense loud speaker. The airborne noise passes through walls via any openings, i.e. small holes, cracks, HVAC ducts, and waveguides, into surrounding spaces within and possibly beyond the confinements of the building. Acoustic energy can transmit across distances of significant length.

Examples of airborne acoustics issues may include the following (not limited to only these) :

- MR Operator exposure at Operator Workstation (i.e. Operator viewing in-line with the patient inside the magnet may require a higher acoustic attenuation window)
- Image reading rooms adjacent to Magnet Room, may be separated by hallways
- Secretarial, offices, meeting rooms, patient rooms (ICU, exam, primary care, etc.)
- Adjacent residential areas/spaces
- In-house library facilities

5.1.2 Structureborne

The structureborne transmission path is the result of mechanical excitation of the floor/building structure causing the building to vibrate. The vibration of the surfaces at surrounding spaces then radiates as acoustic noise. Acoustic energy can transmit across distances of significant length.

NOTE: Less than 5% of installed base sites have experienced structureborne acoustic issues.

Examples of structureborne acoustics issues may include the following (not limited to only these):

- Areas directly above or below the Magnet Room, may not always be an issue
- Image reading rooms adjacent to Magnet Room, may be separated by hallways
- Secretarial, offices, meeting rooms, patient rooms (ICU, exam, primary care, etc.)
- Adjacent residential areas/spaces
- In-house library facilities

5.2 Acoustic Design Guidelines

5.2.1 Magnet Room

Noise generated by the MR system is inherent to the operation of the system. The sound quality (human perception) within the Magnet Room can be modified by including sound absorbing materials to make the room sound more subdued and less harsh. The measured sound levels via a sound level meter will not change. However, the measured sound levels can be reduced only when the sound level generated by the MR System is reduced.

Sound quality improvements can be achieved by the following:

- Use ceiling tiles with fiberglass panels having a 2 inch (51mm) thickness set into the standard T-bar grid system.
- Adding fiberglass panels to the side walls covering approximately 20% of the side wall surface area. The panels should focus on covering the top half of the side walls. Panels could take many different and decorative shapes to improve the sterile look of the rooms. Typically panels might be on the order of 4 ft x 6 ft (1.2 m x 1.8 m) with a thickness of 4 inches (102 mm) or equivalent. Panels shape could vary to produce mosaic effects to meet the customer preference. Any decorative materials used to cover the wall panels must be porous so that sound waves can pass through with ease. In principle, a person should be able to breath through the material with ease. Fire retardant cloth should be used. The NRC (Noise Reduction Coefficient) of the panels should be 0.95 or better when mounted against a hard surface such as drywall or concrete.

5.2.2 Inter-Spacial Areas

Acoustic Noise Control to mitigate noise from being transmitted to other spaces often amounts to paying attention to small details while working with ordinary construction materials. The key objectives are to eliminate all cracks and gaps in the wall construction while making sure that the doors, walls, floor, and ceiling have adequate transmission loss via mass or special double wall construction along with good fitting massive doors.

The entire Magnet must be surrounded by walls with substantial mass and/or double wall construction so that noise is contained in the room and not allowed to pass through into nearby spaces. Wall junctions must be sealed with acoustical sealant so that noise waves to do not escape from the room. In principle, if the room were filled with smoke and under a positive pressure, no smoke would leak from the room.

5.2.2.1 Wall Construction

Wall Construction will entail ordinary building materials in a careful configuration.

- The preferred wall would have an ASTM STC 50 construction which entails the use of standard wall construction of steel studs (typically 3-5/8 inch (92 mm)) with 2 layers of Type X drywall (typically 5/8 (16 mm)) on each side totaling 4 layers and fiberglass batt in the stud cavity. All drywall must be overlapped by 6 inches (152 mm) or more. Beads of (USG) Acoustical Caulking (non-hardening) would be used around the entire perimeter of the drywall. Any form of wall penetration should be avoided. Any necessary wall penetrations must be sealed using

combination of Acoustical Caulking (non-hardening) and fiberglass batt material. See examples of wall construction shown in Illustration 7-9 and Illustration 7-10.

- The top of the wall must join the ceiling/floor above so that no cracks or gaps occur. If metal pan is used on the ceiling/floor (above), then flute seals would be used to seal the gaps between the drywall and the pan. Alternately drywall can be cut out to fit into the flutes. Acoustical caulking (non-hardening) will be used to seal the remaining cracks and gaps.

Illustration 7-9: Example Of Wall Construction For Airborne Noise Control - Option 1

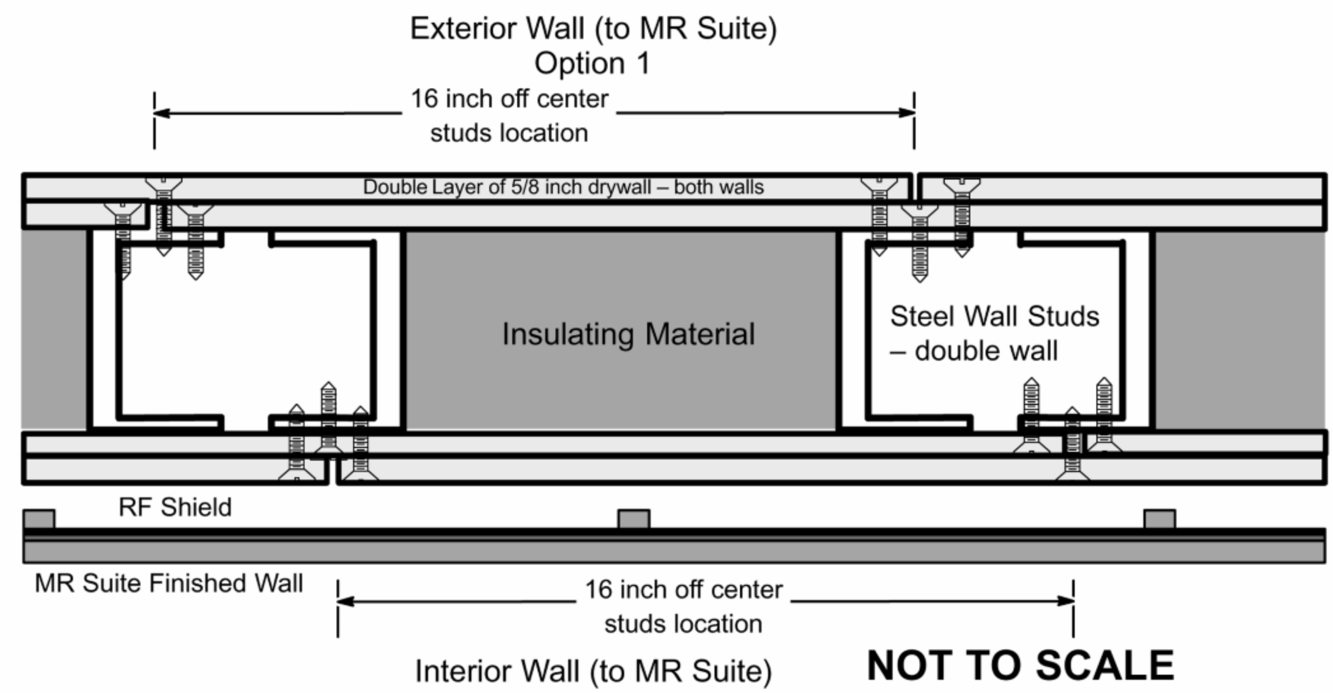
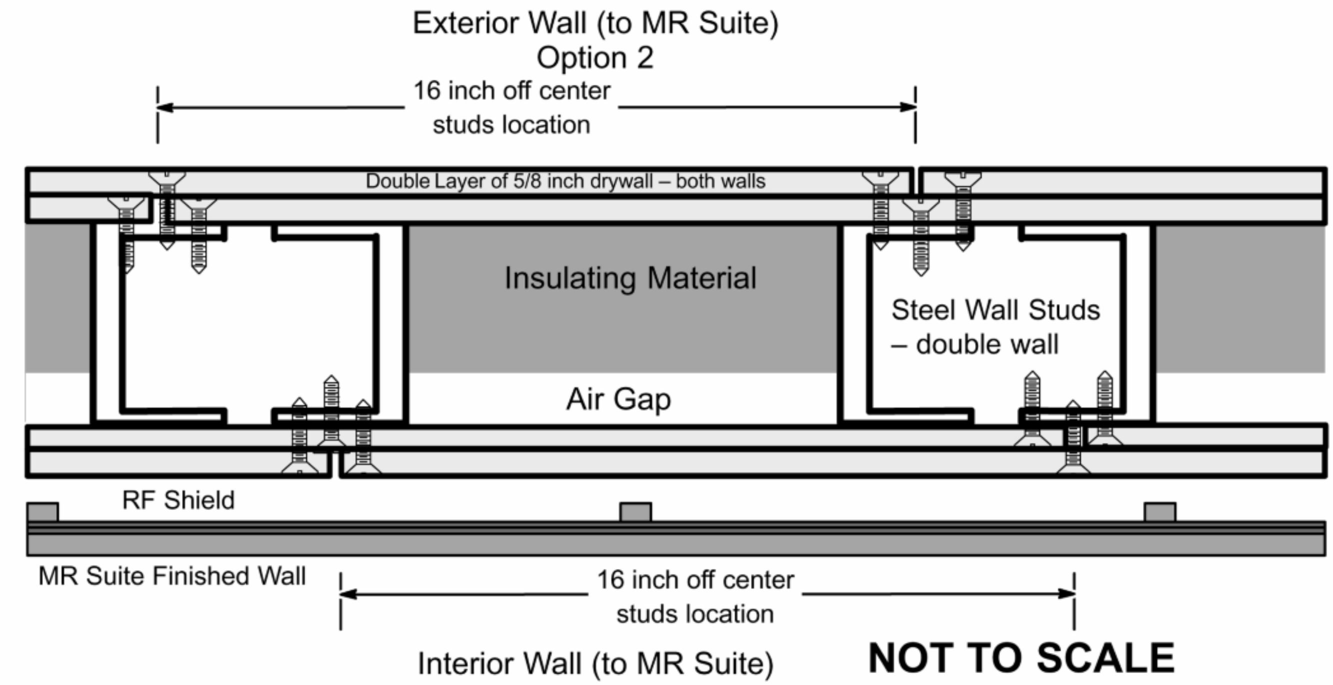


Illustration 7-10: Example Of Wall Construction For Airborne Noise Control - Option 2



5.2.2.2 High Bay RF Room

A high bay RF Room is a self contained RF Room which has open air space between the RF Room ceiling and the building floor above. The air space is an acoustic transmission path. Acoustic energy must be reduced to minimize this transmission of energy through this path.

In cases where the Magnet is to be installed in a high bay, it may be most effective to enclose the RF Room with its own drywall and steel stud room. The key difference being a ceiling assembly that mimics the sidewall construction to contain noise.

- Normal high STC stud walls from above would be used to support a ceiling assembly constructed of structural C channel with two layers of drywall on each side (total of 4 layers) with fiberglass batt in the cavity.
- Penetrations should be avoided via the use of surface mounted lights. HVAC and ducts passing through the ceiling, party wall or side walls would require acoustic noise attenuation in the form of inline silencers. Gaps and cracks would be sealed between the ceiling, party wall or vertical side walls and the cryogen vent plumbing. In essence the Magnet would be enclosed in a drywall "doghouse".

5.2.2.3 Miscellaneous Plumbing, RF Windows and RF Doors

Other construction details are equally important to mitigate noise transmission to meet the intended goal.

- Pipes (gas or water) and electrical conduit or Magnet Room signal cables must be sealed where they penetrate the walls or ceiling. A heavy mastic material such as Duxseal™ is appropriate.

- RF windows should be purchased as window/frame units with an STC rating obtained from laboratory testing per ASTM standards. STC 50 to 60 windows are needed. The installation must include proper sealing to avoid sound leaks.
- RF doors should be selected to provide an STC 50 to 60 to quell the noise. Contact RF Shield Room supplier for selection of RF doors that meet the local acoustic codes and site acoustic requirements. RF door seals must be selected to prevent small gaps around the door perimeter and at the door threshold. RF door seals would either require periodic replacement or a door seal that would last the life of the Magnet Room.

6 Sample Calculation AC Power Equipment Minimum Distance

This is a sample calculation to determine minimum distance from a feeder, transformer, or other AC electrical source, using the Formula found in Chapter 2, MR Suite Magnetic Field Specifications Electrical Current subsection to determine minimum distance from a feeder, transformer, or other AC electrical source.

I (amps) = $20X^2$ (meters) ÷ S (meters)

Note that the formula has 3 variables, if you have 2 of them, you can calculate the 3rd. In this example, we calculate the minimum distance **X** from the source, in this case a main electrical feeder carrying 450 amps of current in a 5 inch conduit.

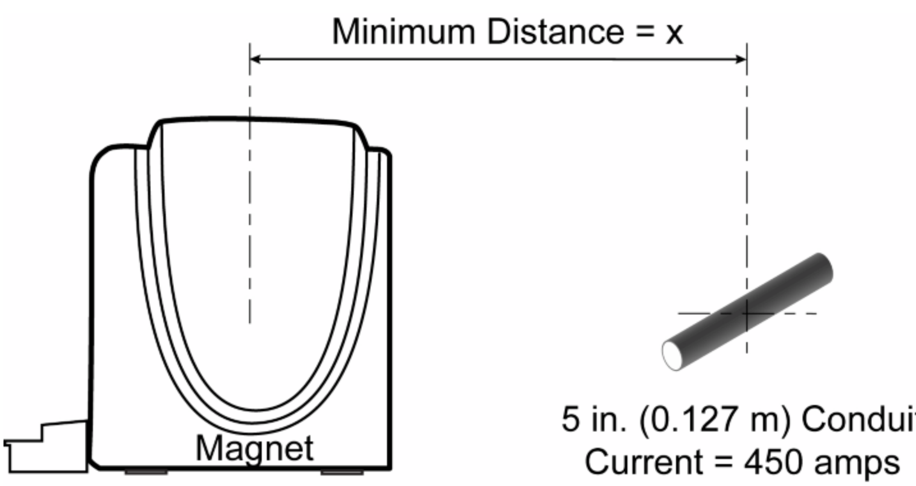
$$x^2 \text{(meters)} = \{\text{I (amps)} \times \text{S (Meters)}\} / 20$$

Rearranging:

$$x = \sqrt{\left\{\frac{\{\text{I (amps)} \times \text{S (Meters)}\}}{20}\right\}}$$

Note that the separation “S" is the spacing between the conductors and when all 3 conductors are run in a single conduit, “S" is simply the diameter of the conduit.

S = 5 inches = 0.127 meters



$$x = \sqrt{\left\{\frac{\{450 \text{ (amps)} \times 0.127 \text{ (Meters)}\}}{20}\right\}}$$

The conduit should be 1.7 meters or 5.6 feet from the magnet isocenter.

In other situations, the spacing “S" may be the spacing between HV feeders, the distance between transformer lugs, or the spacing between conduits when the phase conductors are run in separate conduits.

What if it is too close? Keep in mind that if this is an existing condition, you should request an *EMI study* to quantify the magnitude and direction of the AC disturbances. The calculation is worse

case and does not take into account the vector direction of the AC interference. The magnet is only sensitive to AC disturbances that are directed horizontally (magnet z-axis). Also the calculation does not account for any magnetic shielding effect of steel conduit.

7 Selecting Magnet Anchor Size

The following is an example to illustrate the selection of proper anchors to install a Magnet in a building with 2000 psi (13.8 MPa) concrete. For this example the area is not under seismic requirements.

1. Determine magnet clamping force (for the Magnet: 2500 lbs + 200 lbs = 2700 lbs or 11,100 N + 900 N = 12,000 N).
2. Refer to the examples of anchor vendor catalogs below to select anchor diameter and embedment which meets the clamping force (tension) determined in Step 1.

   Diameter : Min. 0.625 inch Max. 1.25 inch

   For 8 inch embedment select 3/4 inch diameter

   For 4.5 inch embedment select 1 inch diameter

   or

   Diameter : Min. M16 Max. M32

   For 130 mm embedment select M20 diameter

   For 114 mm embedment select M24 diameter
3. The vendor instructions and torque to the maximum recommended level for the anchor selected in Step 2 must be provided to the RF Shield Room vendor for proper installation of the anchor and equipment.

Illustration 7-11: Allowable Anchor Loads in Concrete (English Units)

ANCHOR DIAMETER in. (mm) See Note 1	EMBEDMENT DEPTH in. (mm)	2000 psi (13.8 MPa)		3000 psi (20.7 MPa)		4000 psi (27.6 MPa)		6000 psi (41.4 MPa)	
		TENSION lb (kN)	SHEAR lb (kN)	TENSION lb (kN)	SHEAR lb (kN)	TENSION lb (kN)	SHEAR lb (kN)	TENSION lb (kN)	SHEAR lb (kN)
5/8 (15.9)	2 3/4 (70)	1250 (5.6)	2800 (12.5)	1600 (7.1)	3070 (13.7)	1810 (8.1)	3330 (14.8)	1920 (8.5)	3330 (12.5)
	4 (102)	1870 (8.3)	3330 (14.8)	2400 (10.7)	3330 (14.8)	2930 (13.0)	3330 (14.8)	3200 (14.2)	3330 (12.5)
	7 (178)	2500 (11.2)	3330 (14.8)	3010 (13.4)	3330 (14.8)	3650 (16.2)	3330 (14.8)	3650 (16.2)	3330 (12.5)
3/4 (19.1)	3 1/4 (83)	1550 (6.9)	2880 (12.8)	1950 (8.7)	3310 (14.7)	2350 (10.5)	3730 (16.6)	2610 (11.6)	4800 (21.4)
	4 3/4 (121)	2510 (11.2)	4510 (20.1)	3250 (14.5)	4650 (20.7)	3870 (17.2)	4800 (21.4)	4670 (20.8)	4800 (21.4)
	8 (203)	2930 (13.0)	4800 (21.4)	3870 (17.2)	4800 (21.4)	4530 (20.2)	4800 (21.4)	5120 (22.8)	4800 (21.4)
1 (25.4)	4 1/2 (114)	3120 (13.9)	6080 (27.0)	3870 (17.2)	6770 (30.1)	4610 (20.5)	7470 (33.2)	4800 (21.4)	7470 (33.2)
	6 (152)	4400 (19.6)	7470 (33.2)	6400 (28.5)	7470 (33.2)	7200 (32.0)	7470 (33.2)	7330 (32.6)	7470 (33.2)
	9 (229)	5600 (24.9)	7470 (33.2)	8000 (35.59)	7470 (33.2)	9390 (41.77)	7470 (33.2)	9390 (41.8)	7470 (33.2)
Note 1 All shaded values fail to meet the clamping force (tension), therefore are not acceptable anchors.									

Illustration 7-12: Allowable Anchor Loads in Concrete (Metric Units)

ANCHOR DIAMETER See Note 1	EMBEDMENT DEPTH mm (in.)	13.8 MPa (2000 psi)		20.7 MPa (3000 psi)		27.6 MPa (4000 psi)		41.4 MPa (6000 psi)	
		TENSION kN (lb)	SHEAR kN (lb)	TENSION kN (lb)	SHEAR kN (lb)	TENSION kN (lb)	SHEAR kN (lb)	TENSION kN (lb)	SHEAR kN (lb)
M16	105 (4 1/8)	11.2 (2500)	25.1 (5650)	20.9 (4705)	39.9 (8965)	24.2 (5450)	10125 (45.0)	6900 (30.7)	10550 (46.9)
M20	130 (5 1/8)	25.1 (5650)	52.9 (11900)	30.7 (6910)	58.7 (13195)	36.4 (8175)	14490 (64.5)	10005 (44.5)	14490 (64.5)
M24	155 (6 1/8)	30.0 (6735)	61.2 (13760)	36.9 (8300)	70.5 (15855)	43.9 (9860)	29.8 (17950)	57.7 (12980)	95.6 (21490)

Note 1 All shaded values fail to meet the clamping force (tension), therefore are not acceptable anchors.

8 Magnet Cryogenic Venting Pressure Drop Reference Tables

Use the following tables to calculate the cryogenic vent pressure drop through the pipe used.

Table 7-2: 1.5T Magnet Cryogenic Vent System Pressure Drop Matrix

Inside dia. of vent pipe (D)	Distance of vent system component from magnet		Pressure drop for straight pipe with smooth inside surface		Pressure Drop Per Elbow Used Anywhere Within A 20 Ft (6.1 M) Vent Segment							
					Standard Sweep				Long Sweep			
					Std sweep 45° elbow ($K = 15\ F_t$)		Std sweep 90° elbow ($K = 30F_t$)		Long sweep 45° elbow ($K = 7.5F_t$)		Long sweep 90° elbow ($K = 15\ F_t$)	
	ft	m	psi/ft	kPa/m	psi	kPa	psi	kPa	psi	kPa	psi	kPa
8 in. (203.2 mm)	00- 20	0 -6.1	0.10	2.26	1.10	7.58	2.06	14.20	0.55	3.79	1.03	7.10
	20- 40	6.1 -12.2	0.21	4.75	2.10	14.48	3.70	25.51	1.03	7.10	1.85	12.76
	40- 60	12.2 -18.3	0.30	6.79	2.88	19.86	5.21	35.92	1.44	9.93	2.60	17.92
	60-80	18.3-24.4	0.38	8.60	3.70	25.51	6.71	46.27	1.85	12.76	3.36	23.17
	80-100	24.4-30.5	0.47	10.63	4.52	31.17	8.22	56.68	2.26	15.58	4.11	28.34
10 in. (254.0 mm)	0- 20	0 - 6.1	0.03	0.68	0.55	3.79	0.82	5.65	0.27	1.86	0.41	2.83
	20- 40	6.1 -12.2	0.07	1.58	0.82	5.65	1.51	10.41	0.41	2.83	0.75	5.17
	40- 60	12.2 -18.3	0.10	2.26	1.23	8.48	2.19	15.10	0.62	4.27	1.10	7.58
	60- 80	18.3 -24.4	0.12	2.71	1.51	10.41	2.74	18.89	0.75	5.17	1.37	9.45
	80- 100	24.4 -30.5	0.16	3.62	1.92	13.24	3.43	23.65	0.96	6.62	1.71	11.79
12 in. (304.8 mm)	0- 20	0 - 6.1	0.013	0.29	0.27	1.86	0.41	2.83	0.14	0.97	0.21	1.45
	20- 40	6.1 -12.2	0.027	0.61	0.41	2.83	0.82	5.65	0.21	1.45	0.41	2.83
	40- 60	12.2 -18.3	0.041	0.93	0.55	3.79	1.10	7.58	0.27	1.86	0.55	3.79
	60- 80	18.3 -24.4	0.054	1.22	0.69	4.76	1.37	9.45	0.34	2.34	0.69	4.76
	80- 100	24.4 -30.5	0.069	1.56	0.96	6.62	1.51	10.41	0.48	3.31	0.75	5.17
	100-120	30.5-36.6	0.08	1.81	1.09	7.52	1.77	12.20	0.55	3.79	0.88	6.07
	120-140	36.6-42.7	0.10	2.26	1.27	8.76	2.07	14.30	0.63	4.34	1.04	7.17
	140-160	42.7-48.8	0.11	2.49	1.43	9.86	2.36	16.30	0.72	4.96	1.19	8.21
	160-180	48.8-54.9	0.12	2.71	1.60	11.00	2.53	17.40	0.80	5.52	1.27	8.76
	180-200	54.9-61.0	0.17	3.85	1.75	12.10	2.93	20.20	0.88	6.07	1.47	10.14
14 in. (355.6 mm)	0- 20	0 - 6.1	0.008	0.055	0.20	1.38	0.301	2.08	0.102	0.70	0.15	1.03
	20- 40	6.1 -12.2	0.017	0.12	0.30	2.07	0.602	4.15	0.154	1.06	0.30	2.07
	40- 60	12.2 -18.3	0.026	0.18	0.40	2.76	0.808	5.57	0.198	1.37	0.40	2.76
	60- 80	18.3 -24.4	0.034	0.23	0.51	3.52	1.01	6.96	0.250	1.72	0.51	3.52
	80- 100	24.4 -30.5	0.043	0.30	0.71	4.90	1.11	7.65	0.353	2.43	0.55	3.79
	100-120	30.5-36.6	0.050	0.34	0.80	5.52	1.30	8.96	0.40	2.76	0.64	4.41
	120-140	36.6-42.7	0.063	0.43	0.933	6.43	1.52	10.48	0.46	3.17	0.76	5.24
	140-160	42.7-48.8	0.069	0.48	1.05	7.24	1.73	11.93	0.52	3.59	0.87	6.00
	160-180	48.8-54.9	0.076	0.52	1.18	8.14	1.85	12.76	0.59	4.07	0.93	6.41
	180-200	54.9-61.0	0.11	0.76	1.29	8.89	2.15	14.82	0.64	4.41	1.08	7.45

Inside dia. of vent pipe (D)	Distance of vent system component from magnet		Pressure drop for straight pipe with smooth inside surface		Pressure Drop Per Elbow Used Anywhere Within A 20 Ft (6.1 M) Vent Segment							
					Standard Sweep				Long Sweep			
					Std sweep 45° elbow ($K = 15 F_t$)		Std sweep 90° elbow ($K = 30F_t$)		Long sweep 45° elbow ($K = 7.5F_t$)		Long sweep 90° elbow ($K = 15 F_t$)	
	ft	**m**	**psi/ft**	**kPa/m**	**psi**	**kPa**	**psi**	**kPa**	**psi**	**kPa**	**psi**	**kPa**
16 in. (406.4 mm)	0- 20	0 - 6.1	0.0053	0.037	0.153	1.05	0.230	1.59	0.078	0.54	0.115	0.79
	20- 40	6.1 -12.2	0.013	0.09	0.229	1.58	0.460	3.17	0.118	0.81	0.229	1.58
	40- 60	12.2- 18.3	0.020	0.14	0.306	2.11	0.618	4.26	0.152	1.05	0.306	2.11
	60- 80	18.3 -24.4	0.026	0.18	0.390	2.69	0.773	5.33	0.191	1.32	0.390	2.69
	80- 100	24.4 -30.5	0.033	0.23	0.543	3.74	0.850	5.86	0.270	1.86	0.421	2.90
	100-120	30.5-36.6	0.038	0.26	0.613	4.23	0.995	6.86	0.310	2.14	0.490	3.38
	120-140	36.6-42.7	0.048	0.33	0.714	4.92	1.16	8.00	0.352	2.43	0.581	4.01
	140-160	42.7-48.8	0.052	0.36	0.803	5.54	1.32	9.10	0.398	2.74	0.666	4.59
	160-180	48.8-54.9	0.058	0.40	0.903	6.23	1.42	9.79	0.451	3.11	0.712	4.91
	180-200	54.9-61.0	0.084	0.56	0.987	6.81	1.64	11.31	0.490	3.38	0.826	5.70

Notes

1. Elbows with angles greater than 90° **must not** be used.
2. The table data is based on the followings:
    a. Initial flow conditions at magnet interface
    b. Gas temperature starting at 4.5 Kelvin (-452° F or -268°C).
    c. Helium gas flow rate of 2,737 cubic feet per minute (77.5 cubic meters per minute)
    d. 45° standard sweep elbow $K = 15 F_t$
    e. 90° standard sweep elbow $K = 30 F_t$
    f. 45° long sweep elbow $K = 7.5 F_t$
    g. 90° long sweep elbow $K = 15 F_t$

GE Medical Systems, a General Electric Company, going to market as GE Healthcare.
3200 N. Grandview Boulevard
Waukesha, Wisconsin 53188
USA

www.gehealthcare.com